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GENERAL
ANATOMY,

APPLIED TO

PHYSIOLOGY AND THE PRACTICE OF MEDICINE,

BY

X. BICHAT,

TRANSLATED FROM THE LAST FRENCH EDITION,

By CONSTANT COFFYN.

REVISED AND CORRECTED

By GEORGE CALVERT, Esq.

MEMBER OF

THE ROYAL COLLEGE OF SURGEONS, &c.

VOL. I.

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TO THE

PRESIDENT, FELLOWS, AND MEMBERS

OF

THE ROYAL COLLEGE OF SURGEONS,

THIS TRANSLATION

OF

BICHAT'S ANATOMY

IS MOST RESPECTFULLY DEDICATED

BY THEIR VERY OBEDIENT SERVANT,

CONSTANT COFFYN.

TRANSLATOR'S PREFACE.

From the very high reputation that Bichat has deservedly obtained, and the flattering manner in which his Works in general have been received and extensively diffused, it is conceived that little apology will be deemed requisite for having undertaken this Translation. Unfortunately, the career of this celebrated Writer was as limited as it had been brilliant; which, whilst it is deeply regretted by every one connected with the Medical Profession, and more especially from the circumstances by which it was terminated, is an additional motive for profiting by what he has written,—since the comparative value of a work is generally, and with justice, considerably enhanced when the intelligent source from which it has sprung has ceased to exist.

Had Bichat lived to a more advanced age, there can be no doubt that his name would hereafter have been numbered amongst the first of those who, by a rare union of imagination, deep research and unwearied industry, have advanced and done honour to the Profession they embraced, and without any feeling of partiality it may be said that it has still a powerful claim to our admiration and respect.

The subject matter of the Work is noticed by the Author in his preface, and its general merits are too well known and appreciated to stand in need of an encomium. It has, indeed, been objected, and with some truth, that it is too diffuse and somewhat obscure, but if we consider that it comprises the sum of his lectures, and was no doubt published principally for the use of Students, the former objection will have much less weight, and the latter, indeed, where it exists, has, it is presumed, been remedied by endeavouring to give the full meaning of the original in somewhat less compass and with more point.

As a foreigner, a revision of my work was indispensable, and in this respect I have to acknowledge myself much indebted to the abilities and kindness of Mr. Calvert.

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END OF THE ANALYSIS OF PART THE FIRST

PREFACE

OF

THE AUTHOR.

THE general doctrine of this work bears little resemblance to that contained in the prevailing works of physiology and physic. Opposite in its nature to Boerhaave's, it differs not only from that of Stahl, but of all others who, like him, have ascribed every thing in the living economy to one sole, abstract and ideal principle, whether it be under the name of soul, vital principle, archæus, &c.

To analyse with precision the properties of living bodies; to demonstrate that every pathological phenomenon is derived from their increase, diminution, or change; that every therapeutic phenomenon has for its object and principle their restoration to a natural state; to mark distinctly those cases in which such phenomena are found to operate; to ascertain, in physiology as in pathology, what proceeds from the one and what from the other ; to determine, therefore, in the most accurate and decisive manner which of the natural and morbid phenomena are regulated by those of animal life, and which are produced by those of organic ; and lastly, to point out when the animal sensibility and contractility, or where organic sensibility or contractilities, sensible or insensible, are called into action : such is the general doctrine of this work. One glance will convince us that it is impossible to define the prodigious influence of vital properties in physiology, without considering them in the points of view I have represented them. It may be said that this manner of investigating them is still theory : to which I answer—the doctrine that demonstrates the laws of gravity, elasticity, and affinity, that proves them to be first principles of all the facts observed in physics, is in this case itself a theory. The relation of properties as causes, with phenomena as effects, is an axiom in philosophy, chemistry, astronomy, &c. it is in these days scarcely worth while to repeat ; and if this work establishes the like axiom in the physiological sciences, it will have attained its end.

GENERAL ANATOMY.

GENERAL CONSIDERATIONS.

There are in nature two classes of beings, two classes of properties, and two classes of sciences. Beings are organic or inorganic, properties vital or non-vital, sciences, physiological, or physical. Animals and vegetables are organic. What are called minerals are inorganic. The vital properties are sensibility and contractility. The non-vital are gravity, affinity, and elasticity. The physiological sciences are composed of animal physiology, vegetable physiology, and physic. The physical sciences are astronomy, natural philosophy, chemistry, &c.

These two classes of sciences belong exclusively to phenomena. Two other classes corresponding to them embrace external and internal forms, and their description. Botany, anatomy, and zoology, constitute the sciences that treat of organic forms; mineralogy, that which treats of inorganic forms. The first will occupy us particularly when we come to examine the connections of living bodies with one another, and those that are inanimate.

SECTION I.

General Remarks on Physiological and Physical Sciences.

THESE distinctions are founded essentially on the difference that exists between the properties presiding over the phenomena which are the subject of each class of science. Such is, in fact, the immense influence of these properties, that they are the first cause of all these phenomena. Let us investigate those of astronomy, hydraulics, dynamics, optics, accoustics, &c. and ultimately we shall be led by a long deduction of causes to gravity and elasticity, as the period of our researches. In the same way the vital properties are uniformly the primum mobile to which we must ascend, whether the phenomena we study are those of respiration, digestion, secretion, circulation, inflammation, or fever, &c.

Nature, in bestowing existence on each individual body, has endowed it with a certain number of properties that characterise it in particular, and in virtue of which it contributes as far as its faculties extend, to all the phenomena which are incessantly developing, connecting themselves together, and succeed each other in the universe. If we cast our eyes around us, or direct them towards the most distant objects; if we take the telescope and survey those bodies that are floating in space, or the microscope, and look into the world of atoms, whose extreme diminutiveness threatened to conceal them for ever from the sight, we shall every where find on one hand the physical, on the other the vital properties, all put in motion; we shall every where see inert bodies gravitating one upon the other, and exerting mutual attraction; every where living bodies gravitating also, but feeling and experiencing moreover a motion which they owe only to themselves. These properties are to that degree inherent in both, that we cannot conceive bodies without them. They constitute their essence and attribute: nor can they exist without enjoying them. Deprive them of these, at that instant all the phenomena of nature cease, and matter exists alone. What was chaos? Matter without properties. God, when he created the universe, endowed it with gravity, elasticity, affinity, &c. and animated a portion of it with two instinctive principles, sensibility and contractility.

This method of describing the vital and physical properties, sufficiently denotes that we need go no further in our explanations, that they afford the principles, and therefore that these explanations must be deduced as so many consequences. Sciences, both physical and physiological, are composed of two things; 1st, the study of phenomena, which are the effects; 2d, the investigation of the connections that exist between them, and the physical and vital properties which are the causes.

It is only of late that these sciences have been thus considered. Every fact individually observed, was in some measure the subject of a particular hypothesis. Newton was one of the first who remarked that, however variable physical phenomena were, they were all derived from a certain number of principles. These principles he analyzed; and proved, above all, that the power of attraction was one of the principal agents amongst them. Attracted by each other, and by their sun, planets describe their eternal curves. Attracted to the centre of our globe, water, air, stones, &c. move, or have a tendency to move towards it. Sublime was undoubtedly that idea which has spontaneously laid the basis for all the physical sciences. Let us thank the immortal Newton, he first discovered the secret of the Creator; namely, the simplicity of causes united with multiplicity of effects.

The era of that great man was the proudest and most memorable in the annals of human understanding. From it we date the establishment of principles, whence facts have been deduced as consequences. But that epoch so peculiarly remarkable for the progress of physical sciences, achieved nothing for physiology. What do I say?—It retarded its course. From that time we heard of nothing but attraction and impulsion in vital phenomena.

Of a bright and felicitous genius, Boerhaave suffered himself to be dazzled by a system that fascinated alike all the spirits of his age, and wrought in physiological sciences a revolution akin to that which the vortices of Descartes introduced in the sciences of natural philosophy. His exalted and illustrious name, and the captivating qualities that were combined with it, secured to this revolution an empire which was long mouldering to decay, though undermined in all parts of its weak and dangerous foundations.

Less brilliant than profound, rich in those arguments, that convince the understanding, without the sophistry that deceives the imagination, Stahl formed for physiological sciences an epoch more worthy of remark than that of Boerhaave. He felt the want of harmony between the physical laws and the functions of animals; and it was the first step towards the dicovery of the vital laws. This discovery, however, he did not make. The soul was every thing to him in the phenomena of life; it was something, however, to have laid aside attraction, impulsion, &c. Stahl felt what was not the truth, but the truth escaped his notice. Several authors have followed him in referring to one sole principle, variously called by authors, every vital phenomenon. This principle, termed vital by Barthez, archæus by Vanhelmont, &c. is an assumption as void of truth as to suppose one sole acting principle governing all the phenomena of physics. Amongst the latter some are derived from gravity, others from elasticity, and others from affinity, &c. So in the living economy, some result from sensibility, and others from contractility, &c.

Dark and inscrutable to the ancients, the laws of life did not begin to be well known until, in the last century, Stahl had already remarked the tonic motions; but he had not generalized their influence. Haller made sensibility and irritability his peculiar study; but in restricting one to the nervous, and the other to the muscular system, this great man did not consider them in their true point of view. He made almost distinct properties of them. Vicq d'Azyr in his physiological division, denominated them functions, and classed them with ossification and digestion, &c.; that is to say, he confounded the cause with the effect.

Thus, notwithstanding the labours of a host of eminent men, we perceive how much physiological sciences still differ from those of natural philosophy. In the latter, the chemist attributes all the phenomena he observes to affinity; the philosopher, in his science, sees nothing but gravity and elasticity around him. In the other sciences, on the contrary, no one has yet ascribed (in a general manner, at least,) the phenomena to the properties from which they are derived. In the mind of the physiologist, digestion, circulation, and sensation, are not in like manner associated with ideas of sensibility or contractility, as the spring of a watch reminds the mechanic that it is elasticity, which is the primum mobile of its motion; or as the wheel of a mill, or any other machine, which the water forces into action as it flows, recalls to the philosopher the laws of gravity. To compare the two classes of sciences together, it is obviously necessary to conceive an accurate idea of the vital properties: if their limits be not well marked, one cannot, with certainty, analyze their influence. I shall be satisfied with making some general considerations on this subject, as I have treated it at sufficient length in my Researches on Life;—what is added here, must be considered supplementary to my observations in that work.

SECTION II.

Of Vital Properties, and their influence on all the Phenomena of Physiological Sciences.

In assigning limits to these properties, we must follow them from bodies, scarcely organized, to the most perfect.

In plants that seem to form the transition, or intermediate links between vegetables and animals, we perceive nothing but an internal motion, which can scarcely be called real; their growth depends as much upon the affinity, and consequently apposition of particles, as on actual nutrition. Notwithstanding, if we examine vegetables more perfectly organized, we shall find them teeming with fluids that circulate through them in a multitude of capillary vessels, that ascend and descend, and are distributed in a thousand different directions, according to the forces that direct them. This continual motion of fluids has no dependance upon physical properties; the vital ones, alone, direct it. Nature has endowed every part of the vegetable with the faculty of feeling the impression of fluids with which its fibres are in contact, and of re-acting upon them in an insensible manner to accelerate their course. I call these two powers—the one, organic sensibility, the other, insensible organic contractility. The latter is rather obscure in most vegetables, as it is in the bones of animals. These two properties not only rule the circulation of the vegetable, which corresponds nearly to that of the capillary system in animals, but also its processes of secretion, absorption, and exhalation. Let us observe, in fact, that these bodies have only such functions as are strictly relative to their properties; that all the phenomena, which in animals are derived from those that they hold in addition to vegetables, as circulation and digestion, to which circulation, sensible organic contractility is necessary; the sensations to which animal sensibility is necessary, locomotion, and voice, &c., to which animal contractility is necessary; let us observe, I say, that these functions are entirely wanting in vegetables, since they have no vital properties to produce them.

For the same reason, the catalogue of their diseases is less numerous. They are exempt from the whole class of nervous diseases in which animal sensibility plays such an active part; from convulsions and palsies, which are produced by an increase or diminution of animal contractility; from fevers and visceral affections, &c., arising from disordered states of the sensible organic contractility, &c. Tumours of different kinds, increased exhalations, marasmus, &c. are the diseases of vegetables: they all suppose a disturbed state of organic sensibility, and insensible organic contractility.

If we pass from vegetables to animals, we shall find, that the last of these, the zoophytes, receive in a bag, which is alternately empty and full, the food intended for their nourishment; that they begin to unite sensible organic contractility, or irritability, with the above properties, which they share with vegetables; and consequently perform various functions, — digestion in particular.

So far, organized bodies live only within themselves: they have no relation with surrounding matter, they are without animal life, or at least, if it exists in the animal plants, its rudiments are so obscure, that they can hardly be distinguished. This life, nevertheless, displays itself in the superior classes, in worms, insects, molluscæ, &c. On the one hand sensations, on the other voluntary motion, which is inseparable from them, are developed, with more or less plenitude. Vital properties necessary to the exercise of these new functions are then super-added to those above. Animal sensibility, and animal contractility, scarcely perceptible in the lowest species, attain different degrees of perfection the nearer we approach quadrupeds: accordingly, sensations and locomotion are more perfect. Sensible organic contractility is increased, likewise, and in proportion, digestion and circulation in the large vessels, &c., over which it presides, are developed in an increasing ratio.

If we were closely to follow the immense series of living bodies, we should see vital properties gradually increasing in number and energy, from the lowest plant to the highest of animals —man; we should see the lowest plants under the influence of vital and physical properties, and all plants subject only to those which belong to insensible contractility and organic sensibility; the lowest animals would be observed to have sensible organic contractility engrafted on these properties, animal sensibility and animal contractility always increasing as they ascend. The phrase by which Linnæus designated minerals, vegetables, and animals, is well known. This would be more correct:—1st. Physical properties in minerals;—2dly. Physical properties, in addition to vital organic properties, (sensible contractility excepted,) in vegetables;—3dly.

Physical properties, in addition to vital organic properties, and animal vital properties, in animals.

Man, and the neighbouring species, which are the peculiar objects of our researches, evidently then enjoy all the vital properties; some of which belong to his organic life, and others to his animal life.

1st. Organic sensibility, and insensible contractility, in the state of health, have evidently all the phenomena of capillary circulation, secretion, absorption, exhalation, and nutrition, under their influence, &c. Therefore, in examining the functions, we must always bear these properties in mind. In the state of disease, all phenomena denoting disorder of the functions, evidently arise from some injury done to these properties. Inflammation—formation of pus—scirrhus resolution — hemorrhage—preternatural increase or suppression of the secretions—increase of exhalation, as in dropsies—diminution, or total suppression—as in adhesions, absorptions, deranged in a similar manner—imperfect nutrition in producing unnatural phenomena, as tumours, cysts, &c.: such is the series of morbid symptoms, that indicate a disordered and disturbed state in the two above properties.

2dly. Sensible organic contractility, which is not, like the preceding, separable from sensibility of the same nature, governs particularly in the state of health, the motions which take place in digestion, and those in the circulation of the large vessels, at least in the venous and arterial circulations, excretions of urine, &c. In the state of disease all the phenomena of vomiting, diarrhœa, and the infinite changes of pulse, are ultimately referable to disordered states of sensible organic contractility.

3rdly. From animal sensibility all external sensations, as sight, hearing, smell, taste, and touch, and all internal sensations, as thirst, hunger, &c. are derived in a state of health. In diseases, what a powerful part is filled by this property! Pain and its innumerable modifications, such as irritation of the skin, throbbing, pulsations, a sense of weight, prickings, dragging weariness, &c. all these are evidences of a change in animal sensibility. A hundred words would not suffice to express the diversity of painful sensations that are excited by disease.

4thly. Animal contractility is the principle of voluntary motion, and the voice. Convulsions, spasms, palsies, &c. &c. arise from a perverted state of this property.

If we examine all the phenomena of physiology and pathology, we shall not find an individual one among them that is not attributable to one of the properties I have described.

The indisputable truth of this assertion leads to an inference not less certain with regard to the treatment of diseases, namely, that all curative means have for their sole object the restoration of the vital properties when disordered to their natural harmony. Such means, as in local inflammation, do not reduce organic sensibility, when increased; such as in œdematious swellings, dropsies, obstructions, &c. do not increase that property when totally diminished; such as in convulsions do not lower the animal contractility, or prove ineffectual to raise it in palsies, &c., have essentially failed in their aim and object, nay, they have been wholly misapplied.

Into what errors have we not fallen in the use and in the denomination of medicines. When the theory of obstruction was in vogue, the class of deobstruents was founded on it. Next the inspissation of humours was broached, and another class—the incisiva as they were called—were invented to thin them. At the same epoch, we heard of diluents and attenuants. The doctrines of acidity of the fluids followed—and a new order of remedies was found to give them consistency: viz. inviscants and inspissants. Those that acknowledged only relaxation or tension of fibre in diseases; or what they termed laxum and strictum, employed their astringents and relaxants. Those on the other hand, that imputed every thing to the excess or deficit of caloric, administered their refrigerants or excitants.

The very same agents were employed under different names, according to the manner in which they were supposed to act. Deobstruent in one case, relaxant in another, refrigerant in a third, the same medicine has been alternately employed in different, nay, in directly opposite views; so true it is, that the mind of man ever wanders from its right course when misled by vague and uncertain opinions. There have been no general systems in the materia medica; but this science has been alternately influenced by the prevailing theories of physic. From hence proceeds that indefiniteness and uncertainty which marks it even in the present day. It is an incoherent mass of incoherent opinions, and probably of all physiologic sciences, that in which the inconsistencies of the human mind are most glaring. What do I say? It is not a science for a methodical and philosophic mind; it is an incongruous combination of erroneous ideas, observations often puerile, means at the best fallacious, and formulæ as fantastically conceived as they are preposterously combined. It is said that the practice of combined physic has something repelling in it. I will say more: in those principles which connect it with the materia medica it is absolutely revolting to a rational mind. Let us expunge from our classes those medicines that have been closely watched and accurately ascertained, as evacuants, diuretics, sialogogues, anti-spamodics, &c. these, indeed, that act on any determined function, and what knowledge shall we be found to possess of the remaining functions?

It is doubtless very difficult to class medicines according to their manner of acting; but at the same time it is undeniable that their aim is to bring back the living powers to that state of natural harmony which subsists in health. The phenomena of disease are but so many indications of certain changes in these powers, and remedies, therefore so many agents to obviate such changes and restore these powers to their natural condition. Each of these properties has unavowedly, then, its peculiar order of appropriate remedies.

1st. We have seen that in inflammations there exists an increase of organic sensibility and of insensible contractility: what then, we must lessen it by means of poultices, fomentations, local baths, &c. In certain deposits, white swellings, &c. these properties are diminished; we must rouse them into action by the agency of spirituous applications and what are called stimulating substances, &c. In inflammation, suppuration, tumours of various kinds, ulcers, local determinations, disordered states of secretion, exhalation and nutrition, medicines act especially on insensible contractility, &c. and lessen, increase, or alter it in some peculiar manner. What we call resolvents, tonics, stimulants, emollients, &c. have all a reference to this property. Let us observe that these medicines are of two kinds, 1st. General: thus the wines, chalybeates, acids, &c. excite and strengthen insensible contractility and the energy of the whole system; these are general tonics, 2dly. Topical: thus this property is locally encreased by nitre in the kidneys and mercury in the salivary glands, &c.

2dly. Several medicines are particularly directed to sensible organic contractility; such are emetics which stimulate the stomach, purgatives and drastics which produce powerful contractions in the intestines. We rarely have recourse to artificial excitement of the heart as we have to that of the intestines. We cannot command its motion as we augment that of the stomach in visceral diseases. This may be attempted at some distant time if it be true that fever is often an instrument of cure, nor will it, according to my judgment, be difficult to discover the means. When the sensible organic contractility is in a state of increase we must reduce it, and resort to such means as act in an inverse way to the preceding; such for example, as calm the irritable action of the stomach or intestines, &c.

3dly. Animal sensibility also demands medicines peculiar to itself. They act in two ways: 1st. By lessening pain in the parts affected; such as various applications made to tumours, obstructions, local determinations, &c. 2dly. By acting upon the brain where the perception of pain exists. Thus all narcotic preparations taken internally, will prevent painful sensations from being felt there, although the cause is still existing. In the ulcerative stage of cancer uteri, the disease runs its course with disastrous activity;

but the prudent physician deadens cerebral action to such a degree, that the brain is no longer capable of the perception of its effects. It is important to distinguish these two actions of medicines on animal sensibility; they are perfectly distinct from each other.

4thly. Medicines also exert a certain influence over animal contractility. Such as produce a strong stimulus externally, as blisters, friction, urtication, &c. frequently restore that property when suspended by paralysis. All these substances, which benumb the cerebral action, intercept its influence from the muscles of animal life; when the muscles, therefore, are in a state of contraction, these substances are real anti-spasmodics.

In submitting these reflections to the public, I do not intend to offer a new plan of Materia Medica. The modus operandi of medicines is much too complicated for them to be reduced to a new system without ample consideration, which, I must confess, I have not yet given them. Besides, an inconvenience, common to all classifications, obtrudes itself here: the same medicine frequently acts on different vital properties. Emetics, in exciting the sensible organic contractility of the stomach, likewise excite the insensible contractility of its mucous glands, and frequently the animal sensibility of its nervous system. The same observation is applicable to stimulants of the bladder and intestines, &c. My only object is to demonstrate that, in the action of substances applied to the body for its cure, as in the phenomena of disease, every thing has a reference to vital properties, and that their increase, diminution, or alteration constitutes ultimately the invariable object of our curative means.

Some authors recognise nothing in diseases but strength and weakness, and in medicines consequently nothing but debilitants and tonics. This idea is in part true, but false if too much generalised. Each vital power has means calculated to excite it when its energy is diminished, and to reduce it when too much increased. Tonics and debilitants are certainly inapplicable to all cases. We cannot reduce animal contractility when augmented in convulsion as we reduce organic insensible contractility, when augmented in inflammation; neither can we increase them by the same means. In a similar manner the morbid changes that organic contractility and animal sensibility undergo are not to be obviated by the like means. Every vital power has certain medicines peculiar to itself. Besides, properties are not only altered in degree but they are also vitiated in kind. The various modifications which insensible contractility and organic sensibility experience produce different kinds of suppuration in wounds, ulcers, different secretions in glands, and different fluids from exhaling surfaces,

&c. Medicines, then, are not only intended to increase or decrease the energies of the vital powers, but also to restore them to the natural harmony from which they had departed.

What I have just said applies also to the strictum and to the laxum of several physicians, who have only these two objects in view. The strictum may be judiciously applied to inflammatory phenomena; the laxum to dropsies, &c.; but what manner of connexion have these two states of organs with convulsions, disorders of intellectual functions, with epilepsy and bilious affections, &c.? It is the especial fault of those who have a general idea in physic, to make every phenomenon conformable to that idea. This vice of generalising too much has, perhaps, been more hurtful to science than that of considering phenomena in a distinct and isolated manner.

The series of considerations I have unfolded suffice to demonstrate, that every where in the physiological sciences, in the physiology of plants and vegetables, in pathology, therapeutics, &c. it is the vital laws which preside over the innumerable phenomena about which these sciences are conversant, that there exists no one single phenomenon which does not flow from these important and fundamental laws as their source. If we were to examine the different branches of physical science, we should find that the physical laws are the final principle of all their phenomena;

but this is so well understood, that it is needless to dwell for an instant on it. I shall now enter into the consideration of an important object, to which we are naturally conducted by the preceding remarks, namely, the comparison of physical phenomena with those of life, or the physical with the physiological sciences.

SECTION III.

Characteristic Marks of Vital Properties compared with those of Physical Properties.

If we balance the phenomena of the physical with those of the physiological sciences, we shall find that their nature and essence are separated by almost immeasurable distance from each other, owing to the total dissimilitude of their respective laws.

The laws of natural philosophy are constant and invariable; they admit neither of diminution nor increase: we know of no instance in which a stone gravitates towards the earth with more than its accustomed force, or where marble possesses more than its ordinary elasticity; on the contrary the vital properties are at every instant undergoing some change in degree and kind; they are scarcely ever the same.

From thence it follows that all physical phenomena are exclusive and invariable; that at all times, and under all circumstances, they are the same; that consequently they may be foreseen, foretold, and calculated; the fall of a weight can be estimated as well as the revolution of a planet, the course of a river, or the ascent of a projectile, &c. The formula once determined, nothing more is required than its judicious application to individual cases. Thus, weights always gravitate by the sequence of odd numbers; attraction constantly takes place in the inverse ratio of the square of the distances. The vital functions, on the other hand, are subject to numberless varieties; they frequently exceed their natural degree, baffle all calculation, and would require as many formulæ as the cases that occur. In their phenomena nothing can be foreseen, foretold, nor calculated; we judge only of them by their analogies, and these are in the vast proportion of instances extremely uncertain.

There are two things in the phenomena of life: 1st. The state of health; 2d. The state of disease. On these two distinct sciences are founded:—physiology, which embraces the phenomena of the first state; pathology, which embraces the phenomena of the second. The history of phenomena, in which vital powers have their natural type, conducts us by a natural consequence to those phenomena, in which the same powers are changed. Now, in physical sciences we only find the first history, and never the second. Physiology is to the motions of living bodies what astronomy, dynamics, hydraulics, hydrostatics, &c. are to inert bodies; consequently, the latter have no sciences corresponding to them, as pathology corresponds to the first. By the same reason, all idea of artificial cure is at variance with the sciences of natural philosophy. A remedy is intended to restore properties to their natural order; physical properties never deviating from that order, do not of necessity require to be restored to it. There is nothing in physics analogous to therapeutics in physiology. We perceive, then, in what way the peculiar inconstancy of vital properties produces that immense series of phenomena which demand a particular class of sciences. What would become of the world if physical laws were subject to the same changes and agitations as the vital laws? Much has been said of the revolutions of the globe, the changes that the earth has undergone, the desolation which ages have gradually wrought in it, on it, and around it, and of which centuries and centuries have rolled away since without affording another instance. What, then; we should witness this rude spectacle of nature in havoc and confusion at every instant, if physical properties bore the same character as the vital ones.

As the phenomena and laws are so different in physical and physiological sciences, these sciences must themselves essentially differ from each other. The manner of representing facts, and searching after their causes, the experimental art, &c., every thing, in a word, must wear a different stamp, and it would be preposterous to confound them together. As physical sciences rose to perfection before the physiological ones, some have thought to illustrate the latter by associating them together, and have egregiously perplexed them: This was inevitable; for, to apply the science of natural philosophy to physiology would be to explain the phenomena of living bodies by the laws of inert bodies. Here, then, is a false principle; and, therefore, all consequences deduced from thence are illegitimate. Let us leave to chemistry its attractions, and to physics their elasticity and gravity. In physiology we must confine ourselves to sensibility and contractility. Some exception must be allowed, nevertheless, for certain cases where the same organ is the seat of vital and physical phenomena, as the ear and eye. In this respect my work differs in its general tenor from those of physiology, and even from that of the celebrated Haller. The works of Stahl have powerfully inculcated the inestimable advantage of laying aside all these pretended collateral aids, which overwhelm the science they profess to support. This eminent physician, however, had not analyzed the vital properties, and, therefore, was inadequate to explain the phenomena in their real aspect. Nothing is more vague and unsatisfactory than these words, vitality, vital action, vital influx, &c. when their sense is not accurately defined. Suppose, that in the physical sciences some vague and general terms had been invented, which correspond alone to the non-vital properties, and conveyed only general and indefinite ideas, if we were to introduce these words every where, if we did not mark what belongs to gravity, what to affinity, and what to elasticity, &c. we should never be understood. The same may be said in the physiological sciences. Our art is deeply indebted to several physicians of Montpellier for having driven the Bœrhaavian theories from the schools, and embraced the opposite ones of Stahl; but in their departure from the false track they were pursuing, they have chosen in turn such wild and tortuous paths, that I doubt much if they will ever find an outlet.

Minds of an ordinary cast dwell in books on every isolated fact they contain; they do not grasp at once the sum and substance of the principles on which they are founded. The author himself often unconsciously follows the impulse that science has received at the epoch in which he writes; but it is this very impulse that arrests and absorbs a mind of superior endowments; so that the doctrines must be absolutely different in physiological and physical books. A different language is in some measure required, for the greatest part of the words which we transfer from the latter to the former are perpetually recalling ideas that have no association with the phenomena they describe. If we look at the living bodies, we shall find them wasted and supplied, incessantly receiving and rejecting new substances, while inert bodies rest uniformly the same, and preserve the same elements till friction or other mechanical causes destroy them. In like manner, we shall see in the elements of inert fluids an unvarying regularity and determined identity in their principles, which are perfectly known when once analyzed; whilst these principles continually changing in the fluids of living bodies demand a thousand analyses, made under every possible circumstance. We shall perceive glands and exhaling surfaces shedding, according to the degree of their vital power, numberless varieties of the same fluid. What do I say? They shed varieties of fluids essentially different; for do we not discern two distinct fluids in the perspiration and urine that are furnished in one state of the body, and the perspiration and urine that are secreted in another? A thousand examples might be produced to prove this assertion.

The vital properties are by nature prone to exhaustion, and are impaired by time in the same body. They are active and unworn in infancy; fixed and stationary, as it were, in manhood; and decrease and decay in old age. It is said, that Prometheus having formed some statues in the image of man, stole lightning from Heaven to animate them. This fire is the symbol of vital properties; as long as it burns life is sustained; but extinguish it, and life ceases with it. It is, then, a part of the essence of these properties to animate nature only for a certain space, and this comprises the necessary limits of life. On the contrary, the physical properties being inherent in matter, never forsake it. Accordingly inert substances have no other limits to their existence but those assigned them by chance.

Nutrition is unceasingly employed in conveying the particles of inanimate bodies to those endowed with life, and vice versa. We can thus easily conceive how matter is and has been constantly acted upon by physical properties in the immense cycle of ages. These properties took possession of them at the very instant of creation, if I may be allowed the expression, and will only forsake them when the world ceases to exist. In passing from time to time through the living bodies, during the space which separates these two epochs, space measured by immensity—in passing, I say, through the living bodies, matter was penetrated at different intervals with the vital properties, which are found in combination with the physical ones. There is then a wide difference in matter with respect to these two kinds of properties: some it enjoys only for an indefinite period, others it possesses in secula seculorum.

I might add to these considerations numberless others, to prove more fully the difference existing between the physical and vital laws, as also that found between physical and vital phenomena, which arise from the former; and, finally, the difference of the general character and methods of the physical and physiological sciences, which are consequential to the two others. I might shew how inert bodies form themselves by chance, by the juxta-position or combination of their integral particles; how bodies, on the contrary, are propagated by a determinate function, namely, generation: how the former grow in the same way as they have been formed, by juxta-position or the combination of new particles; and how the latter, by an internal process of assimilation, which requires some preparatory functions: that the latter are as long as they exist the habitual seat of composition and of decomposition; that the former always remain in the same state, and are subject to no other modifications but those influenced by physical laws or those occasioned by chance; that the former finish their existence as they commenced it, by the operation of mechanical laws, friction, contact, or new combinations; that the latter afford as certain a phenomenon in their natural destruction as in their production; that the latter proceed immediately to a new state when life has forsaken them, undergo putrefaction, desiccation, &c. from which they were previously preserved, because, fettered by vital properties, the physical ones were continually restrained in the phenomena which they tended to produce; that the others, on the contrary, always preserve the same modifications. Destroy a stone or metal, by breaking the one or dissolving the other, and their particles will remain for ever in the same state. Authors however have already pursued this parallel to sufficient extent, we content ourselves therefore with deducing the consequence, already drawn from other facts; I mean the difference of the laws that govern the two classes of phenomena.

But here I must point out an essential difference existing between vital and physical properties: I speak of sympathies.

Inert bodies have no communication in their various parts. If we destroy one extremity of a block of stone or metal, by means of chemical or mechanical agents, &c. we shall not find the other parts impaired in the slightest degree—a force immediately applied is necessary to produce a change in them. On the contrary, every thing is so bound and chained together in living bodies, that no portion whatever can be disturbed in its functions without some other immediately sympathizing with it. All physicians are sensible of the peculiar consent which exists between all our organs: it exists both in the state of health and disease, but more particularly in the latter. How obvious, how easy would be the study of diseases, were they uninfluenced by the accidents of sympathy. But who does not know that they frequently preponderate over those that depend immediately on the disorganization of the affected organ? Who does not know that the cause of sleep, exhalation, absorption, secretion, vomiting, diarrhœa, retention of urine, convulsions, &c. has frequently its seat at a considerable distance from the brain, exhalants, absorbents, glands, stomach, intestines, bladder, the voluntary muscles, &c.?

Be this as it may, if we reflect never so little on the phenomena of sympathy, we shall perceive that they are unnatural excitements of the living powers which are produced in an organ by the influence this organ receives from others that are immediately deranged. All the systems are in this respect mutually dependent on one another. This important point of doctrine will be treated at such length in this work, particularly in the chapter on the nervous system, that it is needless, I think, to dwell longer on it here.

We shall see that sympathies always act on the predominating vital properties of one system, on the animal sensibility in the nerves, animal contractility in the voluntary muscles, sensible organic contractility in the involuntary ones, insensible contractility in the glands, in the serous and mucous membranes, in joints, in the skin, &c. We shall see them assuming the character of the vital properties of the organs in which they display themselves, putting on a chronic type in bones, cartilages, &c. and an acute one in the muscles, skin, &c. We shall perceive them in the course of their manifestations, following the laws of nutrition and growth, affecting the nervous and vascular systems, more particularly in the infant, the pulmonary organs in youth, and the abdominal viscera in the adult. But we must proceed to other subjects.

SECTION IV.

Of Vital Properties, and their Phenomena, examined with respect to Solids and Fluids.

Every organized body is a compound of fluids and solids. The former are materials on the one hand, and the residue of the latter on the other. 1st. They are the materials; for from the food which conveys the elements of nutrition to the intestines, to the cavities of the organs where the elements are deposited, &c. they manifestly form part of the chyle and blood.

2dly. They are the residue, since, after having remained some time in the organs, the particles of nourishment are expelled, return to the blood, and are again expelled to form part of the secreted fluids, and those of the skin and mucous membranes which are thrown off externally. There are then fluids belonging to composition, and others to decomposition. The solids are the boundaries where the former which are produced from without terminate, and whence the latter which are expelled from within depart. Fluids of composition or decomposition are not all perfectly distinct: the chyle, matters conveyed through the medium of the skin, the principles which the lungs borrow from air, &c. belong only to the first order. Secreted fluids, and those exhaled from mucous membranes and the skin, appear to belong exclusively to the second. The blood is a common centre, in which those elements that are admitted, and those that are expelled, are blended indiscriminately together.

Let us now consider what part the fluids and solids sustain in vital phenomena. This part evidently depends on the properties with which they are endued: thus, in reflecting on the nature of the vital properties we are acquainted with, it is evident that all pre-conceived ideas of fluids must be dismissed from the mind; that they can never be the seat of any contraction; that organic and animal sensibilities are in no way connected with the state in which their particles are found, &c. I think it needless to speak here of the pretended spontaneous motion of the blood, the subtle fluids it contains, according to some, and which dilate or contract it as occasion may require. All this is but a series of vague ideas, that no experience has confirmed. Besides, in all the phenomena of the living economy the fluids are observed to be nearly in a passive state. The solids on the contrary are always highly active. It is the solids which receive excitement, and which re-act in virtue of that excitement. The fluids are every where excitants, and excitants only. The continual action of the latter on the former gives rise in every part to perpetual sensations which are not referred to the brain, and consequently not perceived. This is organic sensibility in motion; it differs in this respect from animal sensibility, that the soul is not conscious of sensations which do not extend beyond the organs where they take place.

As therefore on one hand, the vital properties reside essentially in the solids, and on the other, morbid phenomena are merely changes of these properties, it is evident that such phenomena essentially reside in the solids, and that fluids are in a certain degree uninfluenced by them. All varieties of pain, and spasm, all these irregular motions of the heart, which constitute the numberless and different states of pulse, have their principles in the solids.

Let us not think, however, that fluids have no concern with diseases; they frequently contain their seeds and germ; they fill the same part as in the state of health, where the solids are the active agents of all the phenomena we observe, but where their action is inseparable from that of the fluids. The stimulus of the fluids is necessary to the contraction of the heart, and the capillary system, &c. As long as they are in their natural state, they produce a natural excitement; but if their nature be once vitiated, if their principles be once changed, that instant they become unnatural stimuli, they excite irregular actions, the functions are disturbed, and disease ensues. We see then that fluids often become the vehicle of morbid matter: but this deserves more detailed consideration hereafter.

The division of fluids into these, of composition and decomposition, is applicable here. The first, which are introduced by the different channels into the body, must resort to the blood which belongs to them in one respect, and, in another, to the fluids of decomposition. It is indisputable, 1st, That chyle may abound in numberless heterogeneous substances, and thus convey into the blood the elements of disease, as when putrid matters, badly digested, and principles of contagion mixed with the food, &c. are received into the primæ viæ. 2dly, We have proofs without number, that absorption by the skin frequently introduces the causes of disease into that fluid. 3dly, That those substances, differing from the constituent principles of air, and calculated for the production of disease, are also accidentally admitted through the medium of the lungs. This is an undoubted fact. Here is then a three-fold gate opened to disease, as we shall have frequent occasion of perceiving in the course of this work. 4thly, There is another accidental one—I mean, incised and lacerated wounds, which frequently convey some destructive principles into the animal economy. These are four heads to which we must refer a multitude of cases in which the fluids are the primary causes of disease, are the essential medium of its principles, and become unnatural stimuli to the solids, producing in them phenomena contrary to the natural order. Thus it appears, that it is the fluids especially intended for the composition of our organs that convey morbific principles; they are the vehicles of disease. On the contrary, fluids intended for decomposition, rid the economy of noxious and offending matters. We have seen that these fluids are every where poured out from the mucous surfaces and skin, either by exhalation or secretion, as perspiration, urine, mucous juices, &c. It is then through their means that the crisis of disease takes place. Physicians have greatly exaggerated the influence of the fluids that are thrown off in morbid states; but we cannot withhold our belief that there is much truth in the doctrine. If these fluids are sometimes the vehicle of disease, it is when they are received into the system contrary to the natural order of the economy, as when bile or urine is absorbed into the circulating mass, &c.

From what has been said, it is evident that diseases, or the combination of symptoms that characterize them, can be only understood by studying the principles which have produced, or keep them in existence. Almost every symptom has a reference to the solids; but the cause may exist in the fluids as well as in them. We may mention a striking example of this in unnatural contractions of the heart, which arise: 1st, because its organic sensibility is increased, while the blood remains the same: 2dly, because the blood is either increased in quantity, as in plethora, or altered in quality, as in putrid fevers, &c. whilst its organic sensibility is unchanged. If there be double excitement, or the organ be twice as susceptible as it should be, the effect is always the same, and acceleration of the pulse follows. It is the solids always that play the principal part in diseases: it is the solids always that contract; but in the first case the cause is within; in the second, without.

This example affords us an idea of what occurs in diseases. In all it is the solids that are especially in action; but it is sometimes within, sometimes without, that the cause of this action exists. It would doubtless be a point of some importance to mark the distinction in these two cases. It is contained in the following remarks:

1st. I divide diseases connected with the question we are discussing into two differest classes: 1st, into those which disturb animal life in partilar; 2dly, into those which especially affect organic life.

I say, especially; for such is the intimacy of relation between these two lives, or species of life, that it is hardly possible for one to be changed without impairing the other. Thus fevers that disturb organic life excite an irritable action in the brain, which affects animal life. Thus primary affections of the brain influence circulation and respiration through the medium of sympathy, &c. &c. But undoubtedly it cannot be denied that there are affections whose principal and primary character denote disordered states of animal life, as convulsions, spasms, palsies, mania, epilepsy, catalepsy, &c. Therefore it appears that the principles of these diseases are almost exclusively seated in the solids, and that for the greater part the fluids are by no means affected. Let us observe likewise, that crises also occur in these diseases. Hypochondriasis, hysteria, melancholy, &c. though appearing to reside more particularly in the solids, in some degree, however, appertain to the fluids, as we see in many instances.

Diseases, on the contrary, which affect organic life, more particularly as fevers, inflammations, &c. imbibe their elements as well from the fluids as from solids. On this account it is that these diseases are subject to crises, and are cured by evacuants, alteratives, &c.

2dly. To decide the question respecting the state of the solids and fluids in disease, it is necessary to distinguish the phenomena of those that are sympathetic from those that are produced by a direct excitement. Every phenomenon of sympathy has its principle essentially and necessarily inherent in the solids; in fact, the solids alone re-act on each other, and are connected together by these media which are yet unknown. Vomiting, febrile agitation of the heart, exhalation, secretion, absorption, by sympathy, are dependent on some change which has been wrought by the influence of a part more or less remote over these solids, which are the seat of these phenomena. If the skin be chilled in a state of perspiration, the pleura is immediately affected by sympathy. Cold water taken into the stomach whilst the body is heated, will frequently excite disorder in a distant organ. This is sympathy, and not repercussion of the humors. I have in this work adduced innumerable examples of sympathies in the different systems, so that in no case I believe can we conceive a distinct disease of fluids.

3dly. The distinction of diseases into organic, or such as affect the tissue of organs, and those which leave it unimpaired, is likewise essential here. The first have indisputably their seat in the solids.

4thly. The distinction into acute and chronic diseases, has also its share of importance.

Lastly. Another, not less important, must be made, namely, that of the diseases which are independent of any principle inherent in the economy, and these which proceed from those of a similar principle, as when syphilitic, scrophulous, scorbutic, or herpetic affections are exerting their baleful sway throughout the system, and invade the different organs in succession.

However slightly we may consider diseases under their different aspects, we shall perceive that what is applicable to one class is not so to another. Wherefore it is abundantly obvious that we must not generalize the question, as has been done even at the present period, that an exclusive theory of the solids or fluids is as glaring an absurdity in pathology, as a theory assigning action only to the solids or fluids would be in physiology. There are two errors we have equally to avoid—the one that of particularizing, the other that of generalizing, too much. They conduce both in an eminent and the same degree to false consequences.

Although vital properties have their especial abode in solids, we must not consider the fluids as purely inert. It is certain that those which are subservient to composition are gradually impregnated with a stronger and larger principle of life from the food, out of which they are formed, to the solids upwards. The alimentary mass is less animalized than the chyle, the chyle less than the blood, &c. It would undoubtedly be a very interesting subject of inquiry, to determine how particles hitherto devoid of vital properties, and absolutely enjoying only the physical, should impregnate themselves by degrees with the rudiments of the former,—I say rudiments, for certainly the vital elaboration that fluids undergo in circulating as such in the body, and before they have entered the solids to form a part of them, is the first step to the properties of the latter. The solids would repel an inert fluid introduced into the vessels instead of blood, and designed for their nourishment; in like manner it would be useless to inject in that fluid the materials of these already exhaled and secreted, insomuch as the exhaling and secretory organs would repel these materials, if they had not been previously prepared by assimilation.

To say what that vitality of fluids is, is evidently impossible; but its existence nevertheless is not less real, and the chemist who analyses fluids has but their caput mortuum as it were before him, as the anatomist possesses only the skeleton of the solids he dissects. Let us observe, in effect, that from the moment the principle of life forsakes the fluids they verge on putrefaction, and are decomposed, like the solids when deprived of their vital powers. This principle alone prevented that internal motion which is beyond doubt so highly instrumental to the changes of which the fluids are susceptible. Let us consider what befals us after a meal: there is generally a slight increase of pulse produced by the mixture of nutritive matter with the blood: If we have eaten any pungent and spicy substances, contrary to custom, a sense of general heat, and a thousand strange sensations of weariness and oppression, &c. are attendant on digestion. Need I mention the different species of wine, and their effects, which do not extend to actual intoxication? Who has not a hundred times purchased the sweets of a convivial repast at the expense of a general feeling of nervous excitement and vascular fulness throughout, while wine is circulating with his blood?—who has not observed that different wines produce different effects upon our system? The solids are infallibly the seat of all we then experience, but is not the cause in the fluids? It is the blood that carries with its own particles others that are foreign to it, and stimulates every organ, but more particularly the brain, because spirituous liquors have the same specific effect on this organ that cantharides have on the bladder, mercury on the salivary glands, &c. What I say is so true, that if we introduce wine into the veins of an animal, we shall produce analogous effects.

I cannot forbear relating a fact, which contradicts all that has been lately advanced relative to the incorruptibility of the blood in diseases. Engaged a short time ago in opening a body at the Hotêl Dieu, with MM. Peborde, L'Herminier, and Courder, I found, instead of the black blood that is common to the abdomen, a sanious greyish fluid, which filled all the divisions of the splenic vein, the trunk of the veina porta, and its hepatic branches, so that, on cutting the liver in slices, we could perceive by the oozing out of this matter the various ramifications of the veina porta and veina cava, which contained common blood. The body was so remarkable for its obesity, that I do not recollect ever having seen one like it. This state of fluid certainly did not proceed from the effects of dissolution, so that the blood must have been, while circulating, if not vitiated to this degree, at least very different from its natural state, and absolutely decomposed.

Let us only consider the immense influence that food possesses over the health, structure, and even character of the species. Let us compare nations which live only upon milk, fruit, &c. with those who are addicted to spirituous liquors. Let us remark to what degree the use of alcohol, introduced into the new world, has modified the habits and manners of savages; let us consider the slow and successive influence of regimen in chronic disease, &c. and we shall perceive that in health as well as in disease the alterations of the fluids frequently precede those of the solids, which are only consecutively deranged, for it is an inevitable consequence. The alterations in fluids seem then essentially to depend on the mode of combination between these parts which are not animalized, and those that are.

We should entertain very erroneous notions of the mixture of the blood with foreign substances, admitted through the medium of the intestines, skin, or lungs, if we were to compare it with the mixture of inert fluids and our chemical combinations. Blood enjoys, as it were, the rudiments of organic sensibility. It is more or less disposed, according to the degree of life which connects it with the fluids that it receives, to enter into combination with them, and endue them with a part of the power that it possesses itself. Sometimes it repels for a while, as it were, those substances which are heterogeneous to it. I am convinced that most of the sensations we experience after a meal, and particularly of which spices and spirits have formed an abundant part, do in a great measure proceed from the general commotion in the blood when it is communicating a portion of its vitality to these heterogeneous substances, and a sort of struggle, if I may be permitted the expression, which takes place in the vessels between the living fluid and that which is not yet animalized. Thus we perceive solids contract and shrink as it were from a stimulus which is new to them. Who can tell if the vitality of fluids does not influence their motions? I think it highly probable. I doubt much if fluids purely inert could, were they to exist alone in living vessels, circulate in them like the living fluids. By the same reason, fluids animated with the vital principle could not circulate of themselves in vessels without it. Life then is equally indispensable to both, but these subjects are too obscure to occupy us further.

SECTION V.

Of Properties independent of Life.

These are what may be called the properties of tissue. They are non-existent in inert bodies, and inherent in the living ones, and depend on their texture and the arrangement of their particles, but in nowise on their living power. Death does not destroy them; they adhere to organs when life has forsaken them, yet are increased in energy by it. They are only destroyed by putrefaction or the decomposition of matter. These properties are extensibility and the contractility of texture. I have sufficiently described them in my "Treatise upon Life." I shall, besides, in this have frequent opportunities of detailing their influence on all organs. I am about to examine a property of which very little has been said till now, which chemists have demonstrated in their experiments, and physiologists frequently mistaken for irritability, but which is in effect as completely distinct from it as it is from the contractility of tissue; I mean the faculty of contracting and shortening itself on the application of certain stimuli. This property will be separately examined in individual organs: I shall consider it here under a general point of view.

Every organized part subjected, after death, as well as during life, to the action of fire or of concentrated acids, will start, contract in various different ways, and be almost as agitated as the irritable organs in a state of excitation. This property must, therefore, be considered in the agents which call it into action, in the organs where it resides, and in its phenomena.

1st. Fire is the principal agent of the contraction of fibre. Every living organ exposed to a red heat involuntarily undergoes such contraction in the highest degree. 2dly. The strongest acids rank next to fire; first, the sulphuric, then the nitric, and lastly the muriatic, excite it in a corresponding ratio. They lose this power in proportion as we dilute them, and if naturally weak scarcely possess it in any degree. The strongest alcohol is but a mean agent in producing this effect when compared with the latter. Notwithstanding it contracts the tissue of the parts by degrees, condensing and twisting them at the same time. In making anatomical preparations we therefore take especial care to reduce our alcohol to 26 or even 24 degrees. 4thly. Neutral salts, by absorbing the moisture of animal substances, likewise condense them and harden them in a remarkable degree after a lapse of time. 5thly, When atmospheric air has removed by desication all the aqueous particles of solids, if the latter are still exposed to its action, they will shorten themselves, shrink, and curl up in a slow and insensible manner. 6thly. Alkalies, in whatever strength employed, will never produce any contraction. 7thly. Water seems to operate in an inverse way to this contraction, dilates and expands the soft parts by maceration, so that their particles become separated; it is only when it contains much caloric that it is equal to produce such contraction. This phenomenon takes place some degrees under the boiling point, and is well marked at the actual point of ebullition.

The different agents of which I have spoken produce then two kinds of contractions: 1st, one instantaneous and almost similar to the motion which springs from the irritation of a living muscle; 2dly, the other slow, progressive, and even imperceptible. Fire and very strong acids are especially the agents of the first; the action of neutral salts, air, alcohol, &c. chiefly produce the second.

These two contractions vary essentially in their results. In fact, the state to which the first reduces the organs soon changes if the cause be not withdrawn. Thus fire, in continuing its effects upon solids, soon reduces them to a hard and carbonaceous mass. 2dly. Boiling water, long applied, destroys by degrees the hardness which solids immersed suddenly acquire. As this hardness diminishes, the boiling process goes on by degrees; it attains its highest degree when the soft parts submitted to its action lose their consistency and are reduced to a complete pulp. 3dly. In the same manner organs being suddenly contracted by acids, and consequently hardened, are soon softened by it, and become pulpy. This double phenomenon, which boiling water produces on one hand, and strong acids on the other, has the strongest analogy. One with the other it seems to depend on the same principles; the only difference is, that the softness produced is infinitely more sudden and much more extensive in the latter than the former. The slow and insensible contraction, or more properly hardness, produced by the contact of neutral salts, as alum, muriate of soda, &c. air, alcohol, &c. affords a phenomenon distinct from the first. It is not changed to a state of softness by the prolonged action of the cause which has determined it, nor does it soften the substance in the same slow and gradual manner it has hardened it: what remains is permanently contracted and twisted.

Are these two kinds of contraction different degrees, or do they proceed from distinct principles? I do not know: this at least is certain, that when living solids have undergone the slow and insensible contraction, they are still susceptible of the other. It is well known, that animal texture after undergoing several years of desiccation, contracts the same as if it had just been submitted to the action of fire in a recent state; the same may be said of ebullition and acids. Soft parts that have been macerated some time in alkohol and neutral salts, exhibit the same effect.

All animal tissues are susceptible of sudden contraction, excepting the hair, epidermis and nails, which in some measure have only the rudiments of this faculty. The contractile power is generally more or less sensible in organs according to their fibrous texture. This explains why muscles, tendons, nerves, &c. are most susceptible thereof; organs that have no fibres, as glands, &c. possess it in a minor degree. Slow and progressive contraction is nearly every where the same. Both exist in textures destitute of animal contractility, sensible organic contractility, and contractility of tissue, as well as in those which enjoy them in the highest degree. Thus tendons, fasciæ, and even bones, when deprived of their earthy matter by acids, will contract as well as muscles, skin, &c. This circumstance alone suffices to mark the contractility of contracting bodies separately from that of others, even tho' the distinction were not confirmed by other identifying proofs that I shall bring forward in the sequel.

When a part suddenly contracts, it is reduced to less than half its original length, and is twisted in different ways. If withdrawn suddenly from an acid or boiling water, it will still be found contracted; but draw it out, and it will lengthen and contract again after the elongation of its fibres ceases; so that it has assumed actual elasticity by contraction. This elasticity is remarkable in nerves, tendons, muscles, &c. which were entirely devoid of it, before the mechanical effects of contraction; nor is it the result of slow and progressive contraction produced by alcohol, neutral salts, &c. If we macerate organized substances for a certain length of time, they will, by degrees, lose the power of sudden contraction, which nevertheless is only completely destroyed when maceration has reduced them to a perfect state of putrescency.

If in this state of contraction, tissues are softened by boiling water, and drawn out to their usual length, contraction can no longer be produced, whatever the agent employed may be.

As soon as putrescency begins, the contractile property ceases.

Slow and gradual contraction, is null during life, which opposes an insuperable obstacle to it; but sudden contraction may supervene when its agents have overcome the resistance it affords,—thus the skin is frequently contracted by burns. If it be stript of its epidermis, and a concentrated acid poured upon it, it produces on these parts the same effect it would on any other organ.

From the moment that a part has been contracted in a living subject, it almost infallibly perishes, and can never be restored to its original pliable state; suppuration separates it from the sound parts.

Fluids do not exhibit the phenomena of contraction, the fibrine only excepted; separated from the mass of the blood, it shrinks on exposure to heat.

From what has been said, it is evident that solids are possessed of the faculty of contracting or shortening themselves; this faculty, too, may be excited in different ways. During life it is called into action, First. By the influence of nerves in the voluntary muscles,—this is animal contractility. 2dly. In the involuntary muscles, by the action of stimuli; which constitutes sensible organic contractility. 3dly. In the muscles, skin, cellular membrane, arteries, veins, &c. by the defect of the property of extension; this is the contractility of texture which is wanting, or at least very imperfect in a number of organs, as in nerves, fibres, cartilages, bones, &c. 4thly. by the action of fire and strong acids;—this is contractility by contraction, which is general.

As soon as life has entirely forsaken the muscles, they no longer enjoy the two first kinds of contractility, but the third is still remaining in them, as well as in all other organs that possess them. They also lose this, when they are dried, or are kept some time in water, but even then the fourth species is left them, which is the last that forsakes animal textures, and might be perpetuated for years. After laying bare the cartilaginous parenchyma of bones found in the cemeteries, I have found them visibly contracted on being exposed to fire. I am convinced that this faculty would exist for ages if organic texture could be preserved.

Contractility is then, it appears, a common and general property, inherent in all animal tissues, but which, according to the manner it is excited, offers modifications strongly marked, between which there is no analogy. It is obviously impossible not to make a distinction between the four I have described, or to mistake the insensible contraction, viz. that kind of oscillation, which during life constitutes insensible organic contractility, or the tonic motions.

Among the agents that determine such an

action of muscular fibre, some belong then to life, and others are independent of it; being derived from organization only. All organs are essentially contractile; but these specific causes which occasion contraction, act only on certain tissues. Contraction alone has a general effect.

SECTION VI.

Remarks on the Organization of Animals.

The properties whose influence we have investigated, are not exactly essentially inherent in the particles of matter wherein they reside. In fact they disappear as soon as these particles lose their organic arrangement. To this arrangement they exclusively belong, and it is therefore necessary to consider it in a general point of view.

All animals are compounded of various organs, each of which exercising a separate function, and in a manner peculiar to itself, concurs to the preservation of the whole. These organs are so many distinct and collateral machines, subordinate to the great, and general machine. Each individual machine accordingly is itself composed of several tissues differing in nature, and constituting the real elements of these organs. Chemistry has its simple bodies, which by the various combinations they admit of, form the compound ones: these are caloric, light, hydrogen, oxygen, carbon, azote, phosphorus, &c. Anatomy, in like manner, has its simple tissues, which, by their combinations, form the organs, properly so called. These tissues are 1st. The cellular membrane. 2dly. The nerves of animal life. 3dly. The nerves of organic life. 4thly. The arteries. 5thly. The veins. 6thly. The exhalants. 7thly. Absorbents and glands. 8thly. The bones. 9thly. The medulla. 10thly. Cartilage. 11th. Muscular fibre. 12th. Fibro-cartilaginous tissue. 13th. Muscles of organic life. 14th. Those of animal life. 15th. The mucous membrane. 16th. The serous. 17. The synovial. 18th. The Glands. 19th. The dermis. 20th. The epidermis. 21st. The cutis.

Such are the real organized elements of our frame. Whatever be the nature of those parts which are blended together, theirs remain uniformly the same; as in chemistry, simple substances do not vary, however the compounds they unite to may differ. We shall make these organized elements of man, the especial objects of this work.

The plan of thus separately examining the single tissues of our component parts, is by no means a gratuitous assumption; it rests on undeniable grounds, and I trust it will exercise a wide and powerful influence over physiology as well as on the practice of physic. In truth, under whatever point of view we may examine these tissues, they have no similitude with each other. It is nature and not science that has fixed the boundaries between them.

1st. Forms are every where varied: some are flat, some round; the simple tissues spread themselves only into membranes, are contracted into tubes, or gathered into bundles of fibres; none exhibit externally the same conformation in respect of their properties, thickness or bulk. The difference of forms however may be only adventitious, and the same tissue presents itself in several different states. The nervous tissue assumes the form of a membrane in the retina, and that of cords in the nerves. The fibrous tissue is arranged into fasciculi in ligaments, and converted into membrane in the fasciæ. This does not affect their nature, it is organization and its properties then, whose distinction we must make our peculiar study.

2dly. Organization is never analogous in simple tissues. We shall find it resulting, in fact, both from parts common and parts proper: now, the parts common to organization, are in the first place, very differently arranged in each tissue. Some of them are formed of cellular substance, blood-vessels, and nerves, &c., in abundance; in others one or two of these common systems are hardly to be discerned, and are even entirely wanting.

In some we observe only the exhaling and the absorbing vessels of nutrition; in others we find them in larger numbers, but designed for other purposes. Some organs are covered with a network of capillaries scarcely to be enumerated here. In others this network is hardly perceptible. As to the parts proper, or those which essentially distinguish animal tissue, differences are striking:—colour, thickness, hardness, density, resistance, &c.: nothing is alike single. A glance suffices to shew a thousand attributes characteristic of each, and exclusive of others. Here we meet with a fibrous arrangement, there with a granulated one; again, we have a laminated one and in many instances the areolar, &c. Notwithstanding these distinctions, authors do not agree in respect to the limits of the different tissues. I have, consequently, had recourse to the action of certain chemical reagents to determine this point. I have examined every tissue under the influence of caloric, air, water, acids, alkalies, neutral salts, &c. Desiccation, putrefaction, maceration, concretion, &c., the results of these agents, have variously affected their different textures. Accordingly it will be seen, that in scarcely one case have they been similar; that in these various alterations, each has been affected in its own peculiar way, and furnished its own phenomena. It has been long a subject of keen enquiry and dispute, whether the arteries have muscular fibres or not, or if veins are analogous in their nature, &c. Let us compare the result of my experiments upon the tissues, and the question will be straightly resolved. It should seem at the first glance, that all these researches into the intimate structure of the organs, conduct us to no great results; but I believe they have accomplished a very essential end, that of determining with precision the limits of every organized part; for as the very nature of these textures is unknown, it is requisite to mark them specifically, according to the different results they produce.

3rdly. Nature has not only granted a different organic arrangement to every part, but endowed it also with different properties. We shall observe in the sequel of this work, that those we ascribe to what we call tissue, display infinite degrees of variety from the muscles, skin, cellular membrane, &c. which enjoy them in the highest degree, to the cartilages, bones, tendons, &c. which are almost destitute of them. Need I speak of vital properties? We find animal sensibility preponderating in the nerves; animal contractility in the voluntary muscles; sensible organic contractility constituting the especial property of the involuntary muscles; insensible contractility and sensibility of the same species, which, is not more easily separable from it than the preceding, strongly developed in the glands, the skin, mucous surfaces, &c. We find every one of the single tissues uniting more or less of these properties in different degrees, and animated accordingly with more or less energy. But they do not only vary in the number of the properties allotted to them: when the same properties exist in several, they assume in each a peculiar and distinctive character. This character is chronic, if I may be allowed to express myself thus, in bones, cartilages, tendons, &c.; it is acute in the muscles, skin, glands, &c.

Independently of this general distinction, every tissue has its peculiar mode of action and degree of sensibility, &c.: the whole theory of secretion, exhalation, absorption, and nutrition, is founded on this principle. Blood is a common reservoir, from which every tissue borrows and chooses its materials according to the degree of its sensibility, and appropriates them to itself, retaining or rejecting them subsequently.

Much has been said since Bordieu's time, of the peculiar life of each organ, or that particular character which distinguishes the whole of the vital properties of one organ, from the vital properties of another. Before these properties had been precisely and rigorously analysed, it was evidently impossible to form a correct idea of this peculiar life. From the sketch, therefore, that I have just drawn, it is obvious, that as the greatest part of the organs are formed of very different simple tissues, the idea of peculiar life can only be applied to these single tissues and by no means to the organs themselves.

Some striking examples will illustrate this very important part of my doctrine. The stomach is composed of serous, organic, muscular, and mucous tissues, and in addition to these common tissues, is furnished with arteries, veins, &c. which we must consider separately. Accordingly, if we take a confused and general view of the peculiar life of the stomach, it will be utterly impossible to form a correct and precise idea of it. In fact the mucous surface is so different from the serous, and both so distinct from the muscular, that we could form no clear judgment of them by confounding them in one general consideration. It is the same with the intestines, bladder, and uterus, &c.,—if we do not distinguish the fabric of the tissues that form these complicated organs, the term of peculiar life will offer vague and uncertain ideas. This is so unquestionably true, that we find tissues alternately absent and present in particular organs. Certain parts of the peritoneum, for example, are either included or excluded, in the structure of the visceral organs, according as they are full or empty. Need I speak of the viscera of the thorax? What has the fleshy substance of the heart in common with the membrane that surrounds it? What concern has the pleura with the pulmonary structure?

Or has this tissue in effect any concern with the membrane that lines the brouchia? I might apply the same remark to the brain and its membranes, as well as to the ear, eye, and other organs.

When we study a function, we must consider the complicated organ which performs it in a general way; but if we would be instructed in the properties and life of that organ, we must absolutely resolve it into its constituent parts. So, too, if we are satisfied with general ideas in anatomy, we must examine every organ en masse, but it is imperiously necessary to separate their tissues one by one, if we purpose to go into a minute analysis of their intimate structure.

SECTION VII.

Consequences of the preceding Principles in respect to Diseases.

WHAT I have premised, leads us to very important consequences, relative to acute and chronic diseases of a local kind; for those which, like most of the fevers, do invade all parts of the system at once, cannot be much illustrated by the anatomy of systems. The first deserves our especial notice.

Since diseases are nothing else but alterations of vital properties, and tissues differ so widely in respect of these properties, they must clearly differ also in the diseases incidental to them. Thus in every organ composed of many tissues, the one may be impaired without disorder of the others; this is indeed what happens in the greatest number of cases. Let us take the principal organs for example.

1st. Nothing is more rare than affections of the substance of the brain, or more common than inflammation of the tunica arachnoides, which invests it: 2dly. A single membrane is often diseased in the eye, while others continue healthy in their structure. 3dly. In spasm or paralysis of the muscles of the larynx, the mucous membrane remains entire, and inversely, when the latter is affected, these muscles perform their functions as usual. Morbid states both of its membrane and muscles, are exclusive of the cartilages, and vice versa. 4thly. In the structure of the pericardium, we observe numerous morbid appearances, while the substance of the heart is without a blemish, as also in the structure of the latter without derangement of the former. The ossification of the valves or coats of arteries does not disease the neighbouring parts. 5thly. When the membrane of the brouchia is the seat of inflammation, the pleura is but little affected thereby, and on the other hand, in pleuresy the former is scarcely ever touched. In peripneumony, though we find considerable effusion in the thorax after death, denoting that a high degree of inflammation has existed in the pulmonary structure, its serous and mucous membranes seldom bear the marks of disease. In post mortem researches, we find too that these membranes often escape in Incipient Phthisis.

6thly. We frequently hear a common saying, a bad stomach, a disordered stomach; but in general it implies only a certain condition of the mucous surface. Although this latter furnishes but a scanty and irregular secretion of the gastric juice, and the process of digestion is consequently impaired, its serous membrane and muscular coat exhale and contract in their wonted way. Thus, too, in ascites, where the serous membrane is discharging a redundant quantity of fluid, the functions of the mucous surface are frequently undisturbed, &c.

7thly. All authors have freely and largely discussed inflammations of the stomach, intestines, and bladder, &c. For mine own part, I do believe that at first, this disease scarcely ever affects the whole of these organs, unless in cases where poison or other deleterious substances have acted on them. Acute or chronic disorder affects the mucous surface of the stomach and intestines; serous inflammation affects the peritonæum, and sometimes in the intermediate muscular coat, we meet with a peculiar inflammatory affection which occurs but rarely according to any experience; yet the stomach, bladder, and intestines are not suddenly attacked by these three diseases. A diseased tissue may influence the neighbouring parts, but the primary affection exists only in one. I have opened a considerable number of bodies, in which the peritoneal covering has been inflamed, either in the intestines, stomach, pelvis, or throughout its whole extent; and in very many cases I have found the subjacent organs in structure perfectly sound, even where the affection was acute, and in scarcely one case where it was chronic. I never saw this membrane exclusively disorganized in one of the abdominial viscera, and healthy in its immediate vicinity; its affection extends itself to an indefinite distance beyond, nor can I conceive why authors have suffered its inflammations to pass almost unnoticed. They have charged the subjacent viscera, with what truly belongs, in the greater number of instances, to the peritonæum alone. We meet with almost as many cases of inflamed peritonæum as inflamed pleura; yet strange to say, the former have passed almost unnoticed while the latter have been favoured with peculiar attention. Most frequently that part of the peritonæum corresponding to a certain organ, is more particularly inflamed; as is exemplified in the stomach: This happens also in cases of suppressed lochia and catamenia, where that portion of it lining the pelvis is primarily affected; but the affection soon becomes more or less general, according to the ample evidence that dissection affords.

8thly. Acute and chronic affections of the bladder, and even the womb, have nothing in common with the inflammation of that part of the peritonæum corresponding to these organs.

9thly. It is well known that the diseases of the periosteum, are distinct from those of the bony structure, and inversely, that the medulla may be a long time affected without participation of the bone or membrane. It is certain that the bony, meduleary and fibrous structures have their peculiar diseases which must not be confounded with those of the bones. The same remark applies with great force to the intestines, stomach, &c., in respect to their mucous, serous, and muscular tissues, &c.

10thly. Although the muscular and tendinous structures be united in the same muscle, yet their diseases are separate.

11th. In the same manner the synovial membrane is not subject to the same affections as the ligaments which surround it, &c.

It is my opinion, that the more deeply we study diseases and their phenomena after death, the more forcible and impressive our conviction will be of the necessity of considering local diseases, not with respect to the viscera, the whole of whose structure they do not attack, but to the different tissues which are separately affected.

When the phenomena of disease are the results of morbid sympathy, they are governed by the same laws as when they proceed from immediate derangement. Much has been said of the sympathies of the stomach, intestines, bladder, lungs, &c. I defy any one to form a correct idea of them, if he refers it generally to the organ, without consulting the different tissues. 1st, When the muscular fibres of the stomach are thrown into irregular contractions, by the influence of another organ producing vomiting, its effects are confined exclusively to the serous and mucous membrane, which would otherwise be the seat, the one of exhalation, the other of exhalation and secretion by sympathy. 2dly. When the action of the liver is sympathetically increased, and an unusual quantity of bile secreted, its peritoneal capsule does not secrete any fluid, as it is not affected. It is the same with the kidneys and the pancreas, &c. 3dly. For the same reason, the viscera of the abdomen, which are all covered by the peritoneum, do not partake of the influence of sympathy, to which it is subjected when disordered. This is the case with the lungs and pleura, the brain and the tunica arachnoides, the heart and pericardium, &c. 4thly. It is certain, that in all spasmodic affections, the muscular fibre is alone affected, and not the tendinous. 5thly. What concern has the muscular membrane of the testis with the sympathies of its own structure? 6thly. It is an avowed fact that many, very many of the sympathetic pains we refer to bones, have their exclusive seat in the medulla.

I might produce examples without number to prove that in no instance whatever it is the whole organ that sympathises, but certain parts of the same organ. This is besides a natural consequence arising from the very nature of sympathies. They are nothing, in effect, but disordered states of vital properties: accordingly, these properties, varying in each tissue, their sympathies cannot be alike. Let us consider the character of the fever that is attendant upon the phlegmasiæ. In inflammation of the mucous membranes it is comparatively trifling: in the serous membranes it is uniformly intense; and in the skin it has the peculiar feature of displaying itself several days before the eruption, as Pinel has observed. If we attentively and closely examine it in the inflammations of the different organs, we shall find it abounding in as many varieties and shades of character as there are organs. From whence does this proceed? From the diversity of the relations which unite the heart with each kind of texture: accordingly this diversity of relations is the result of the diversity of vital powers peculiar to each. Let us only consider the diseases of herpes, psoriasis, syphilis, or cancer, &c. when they have ceased to be local, and affect the general constitution: they alternately assail the various tissues according to the relation that exists between them and the organic sensibility of the latter. Thus they almost always attack particular parts, and never the whole economy of one organ: what do I say? If two of these diseases exist at the same time, it is possible for them to exist separately in two separate tissues. Thus, the stomach, intestines, lungs, &c. may be simultaneously affected by two distinct morbid actions, and such as are perfectly independent of each other, because they reside individually in separate textures, the one in the mucous, and the other in the serous, &c.

Let us not, however, exaggerate that independence which exists between the various tissues of an organ in respect to disease, or we shall be deceived in practice. The cellular system is not only a medium of communication between different parts of the same organ, but also between different organs. Thus, in many chronic diseases, parts of the same organ are diseased by degrees, and the whole of its structure is found disorganised after death, although one only of its tissues was originally affected. In cancer of the breast, a small gland at first is perceived to move under the finger; but, ultimately, the glands, cellular membrane, and skin are confounded, and involved in one promiscuous mass. The same occurs in cancer of the stomach, intestines and penis, &c. We observe phthisis merely producing in the beginning, a few small tubercles in the pulmonary structure, and afterwards often attacking the pleura, and bronchial membrane, &c. If we examine the bodies of those that have died of chronic diseases, in their different stages, we shall easily ascertain the following fact, namely, that the disease of one tissue in an organ will extend by degrees to the others, and we should judge very inaccurately of its primary seat, if we were to estimate it from those parts where it is seen in the moment of dissection.

In acute diseases, the continuity of structure is of itself sufficient to create different symptoms in parts that are not affected. When the peritoneum only is inflamed vomiting ensues. Cough, and even copious expectoration are sometimes symptoms, when the pleura only is diseased. Inflammation of the tunica arachnoides is attended by delirium, although this membrane has no concern with the intellectual functions. Diseases of the pericardium frequently derange the action of the heart, &c. We cannot therefore deny, that the affection of one single tissue in an organ will frequently suffice to disturb the functions of all the others; but it is not less on that account the original and sole source of the disease.

I shall now proceed to further considerations, on the influence which the anatomy of organic structure has over diseases.—

Since every organized tissue has every where a general arrangement, and, whatever its situation may be, retains the same structure and properties, &c., its diseases must unquestionably be every where the same. It imports nothing whether it be the serous membrane which is called tunica arachnoides in the brain, or pleura in the lungs, or pericardium in the heart, or peritoneum in the abdomen, &c. The membrane inflames every where the same; its dropsies are every where alike, and throughout its whole extent it is subject to small grey tubercles, like millet seeds, which I have not yet described, although they deserve especial consideration. I have already remarked, and not unfrequently, that these tubercles, peculiar to the serous tissue, are, like most cutaneous eruptions, chronic in their course. I shall speak of them hereafter. The affections of the mucous tissues, whatever organs they belong to, wear almost always the same character, with some exceptions for the varieties proceeding from the difference of structure. It is the same with the fibrous and cartilaginous tissues, &c. The art is deeply indebted to Pinel, who first divided inflammation according to the organs affected, and embraced in one sweeping and comprehensive view its different species as exhibited in the different tissues of the same organ.

There are uniformly two distinct orders of symptoms in inflammation. 1st. Those depending on the nature of the part affected. 2ndly. Those that proceed from the disordered state of its functions. For instance, the character of the pain, the nature of the attendant fever, its duration, termination, &c. are most commonly the same to whatever organ the diseased membrane may belong. If it be the pleura, there is greater oppression in breathing, the cough is dry, &c.; if the peritoneum, there is diarrhœa, or constipation, vomiting, &c.; if it be the tunica arachnoides, derangement of the intellectual functions; if the pericardium there is irregular pulse, &c. The first symptoms belong to every class of disease, the second are exclusively confined to a certain number. The latter therefore are in some measure accidental, and depend on the neighbourhood of the diseased tissue with the adjacent parts; the former possess the greatest importance.

Medicine as yet, has made but a very limited and indefinite progress in its researches on inflammations of divers tissues. Those of the cellular, mucous, serous, and cutaneous, or skin, are sufficiently known, but the others are more obscure. It is undetermined which is attacked in rheumatism, whether tendinous or muscular. I am disposed to believe it is the former. With respect to inflammatory phenomena in cartilages, veins, arteries, and the synovial membrane, &c. scarcely any thing is understood.

An essential distinction is necessary to be observed in these researches, and it is this: first. That particular tissues, such as the bony, muscular of animal life, &c. are exactly the same in every organ where they exist, and consequently their diseases can in no wise differ. 2dly. That others, such as the cutaneous, serous, mucous, &c. do undergo, according to their respective organs, certain varieties of structure and vital properties, which must necessarily modify the general phenomena of that particular class of diseases which affect these organs. 3dly, and finally. That others, as the glandular and muscular of organic life, &c. being very different in each organ, have the general symptoms and nature of their diseases therefore essentially different. These assertions will be proved in the course of this work.

After having shown that the greater number of local diseases generally affect not one particular organ, but a particular tissue in that organ, it will be necessary to explain the differences they display according to the tissues affected. As I shall have to treat this occasionally at some length, in the consideration of the different organs, I merely make cursory mention of it here.

We shall find then that pain is differently modified in each tissue, according to the degree of sensibility it possesses. The pain which is produced from the inflammation of one is unlike that which attends the inflammation of another.

Let us compare the sharp burning pain of erysipelas with the throbbing pain of phlexmon, or the pain of rheumatism with that of an inflamed lymphatic, &c. We shall also perceive that the sensation of heat produced by inflamed tissues has a distinct and individual character; in one case it is acute and cancinating: in another, it is analogous to that excited by the outward application of heat, &c. &c. There are two general causes which occasion the variation of symptoms in diseases: 1st. The nature of the tissue affected; thus, as I have stated, the inflammation of each, gives rise to a different sensation of pain 2dly. The nature of the disease. It is well known, that cancer, whatever be the structure it destroys, is attended by a pain peculiar to itself; that venereal and scorbutic pains, &c. are also peculiar, being modified to a certain degree in each tissue.

The diversity of tissues, not only modifies the nature of symptoms, but also influences their duration. Nothing in this respect is so vague in the practice of physic as the words acute and chronic, as applied to inflammations of the various tissues. In the majority of cases they run their course, rapidly, in the cutis vera, celullar, serous, and mucous tissues, &c.; their progress is, on the other hand, slow, in the bones, cartilages, and fibro-cartilages. We may apply the preceding distinction with some propriety to the same tissue, as, for instance, inflammations of serous, or mucous membranes, and skin, may be acute or chronic; but if we generalise it, it becomes illogical and absurd. An inflammation of the mucous membrane would be chronic if it lasted two months; but this is, nevertheless, the period of an inflammatory attack in the bones. A chronic affection of the same kind would last a whole year or more. Wounds of the soft parts rarely exceed five or six days if they heal by the first intention, but a bone or cartilage requires thirty or forty days for the perfect union of the divided parts. A disease then, as to duration, cannot be divided into acute or chronic, unless it be considered locally in parts of the same organ: if generally considered, the distinction ceases.

Physicians take a narrow and abstract view of almost all diseases. If they speak of inflammation, they represent redness, tension, throbbing, and pain, &c. as its inseparable and uniform properties. If it be suppuration, they take that of the cellular membrane in phlegmon for a common type, without recollecting that this is only one of the modifications of suppuration and its products. The same in respect to gangrene, scirrhous, &c. Nothing is more loose, more unsystematic, and indefinite, than the general ideas advanced in lectures on disease: they are hardly applicable to one or two tissues.

The anatomy of systems not only reflects a strong light upon the history of diseases, but it also alters in some degree our views of morbid anatomy.

Morgagni, to whom we owe so much on this head, and many others to whom the art is not so deeply indebted, have adopted the general order used in descriptions. They have studied the affections of the head, chest, the belly, and extremities, but it is impossible, in pursuing such a method as theirs, to form a general idea of the alterations common to the various tissues. It must of necessity, restrict our ideas to too circumscribed a compass, since it only presents us one single isolated part of a system which comprehends many more. If, notwithstanding this, we arrive at a general knowledge of the affections of each system, we must, doubtless, study them separately, according to the general notions we have of the whole.

It appears to me infinitely more easy first to consider diseases common to each system, and afterwards to study the peculiarities of each organ in the cavity which it occupies.

I divide then morbid anatomy into two parts. The first, comprises the description of the alterations common to each system, whatever be the organ concerned, or the cavity occupied. It is necessary, at first, to explain the different morbid changes of the cellular tissues, the arterial, venous, nervous, bony, muscular, mucous, synoval, glandular, cutaneous, &c.; to examine closely their modes of inflammation, suppuration, gangrene, &c. to describe the various tumours they are subject to, and the various organic alterations they sustain, &c. Some, in this point of view, as the skin, mucous and serous membranes, glands, &c. open a wide and extensive field to the researches of morbid anatomy. Others, as the tendons, muscles and nerves, are less frequently disorganized in structure. We shall find hereafter that nutrition alone is performed in some; that others, on the contrary, are employed besides in exhalation, absorption, secretion, &c.; functions that denote no small energy in the insensible contractility and organic sensibility which preside over all alterations of structure.

After having thus shown the alterations peculiar to each system, whatever organ be deranged, it is necessary to resume the examination of diseases peculiar to each cavity; to consider those that affect the head, chest, abdomen, and extremities, according to their ordinary course. Herein are classed.—1st. Diseases that specially affect the organ toto, and not one tissue only, which seldom happens. 2dly. The character of diseases peculiar to particular parts of certain tissues; that for instance, which marks disease of the serous membrane in the brain, or the mucous in the chest or abdomen, &c.

This course is unavowedly the most natural, although, as in most calculations of man, where nature is forced to conform herself to his ideas, however at variance with her laws, I acknowledge there are many cases that are not strictly reconcileable with this course.

We have, I think, reached an epoch in which morbid anatomy is about to receive a new and unexpected impulse. This science does not only embrace that of organic derangement, produced by the slow and progressive deteriorations of chronic disease, whether they be causes or effects, but likewise a minute and careful examination of all such changes that the subordinate parts of the animal economy may experience, at whatever stage of disease it may be conducted. With the exception of certain kinds of fevers and nervous affections, every thing in pathology is in the reach and grasp of this science. How idle and insignificant do we find the opinions of physicians, and many too of high endowments and great repute, when we examine them not in their books, but in the dead body. The practice of physic has been long excluded from the circle of the exact sciences; but if the study of the dead body and its morbid appearances be combined with a constant, cautious, and rigorous observation of the living body in a state of disease, it will have a clear and undisputed title to be admitted among them, and especially in virtue of its diagnosis. This is the direct and undeviating line that reasonable minds now incline to pursue, and it will, I doubt not, be generally pursued. What may observation avail us if we know not the seat of the evil? We may make clinical notes from sunrise to sunset for twenty years, on diseases of the heart, lungs, or abdominal viscera, at the bed-side of our patients, and what shall we find in them? What but a detailed and circumstantial account of symptoms, which cannot be referred to any legitimate source, and therefore exhibit only a series of unconnected phenomena. Let us study the dead body, and the obscurity, which observation only cannot dispel, will quickly disappear in the evidence it affords.

SECTION VIII.

Remarks on the Classification of Functions.

The plan I have followed in this work, is not the most favourable to the study of functions. Some of them, as digestion, respiration, &c. cannot be properly included, because they do not belong especially to simple systems, but involve several distinct organs. Accordingly, the few remarks I have ventured on functions, are only introduced in a supplementary manner in this work, whose immediate and ostensible object it is to analyze the different simple tissues which form the large vital organs. However, as it is desirable to refer the different facts of physiology it embraces to a certain physiological classification, I shall unfold that which I have adopted in my lectures.

The difficulty and diversity of these distinctions must be well known. The ancient division into animal, vital, and natural functions, rests on such unsure foundations, that it is evidently impossible to raise a superstructure of any method upon them. Vicq-d'Azyr had substituted another, which afforded but few advantages, insomuch as it disunites certain phenomena that are akin to each other, and converts properties, such as sensibility, irritability, &c. into functions. Since this author's time several others have given the authority of their names to other divisions, which are not more methodical, and equally remote from the natural concatenation of vital phenomena.

I have laboured as much as possible, in classifying functions, to follow the track that nature has marked out herself. In my work, on life and death, I laid the foundations of the classification which I followed before I had published the present one. Aristotle, Buffon, &c. discerned two orders of functions in man, one that connects him with the material world, and another that is subservient to his nourishment. Grimaud revived this idea, which is as sublime as it is true, in his lectures on physiology, and his notes concerning nutrition; but in viewing it on too general a scale, he did not analyse it with minute precision; sensations and motions were all the external functions that he acknowledged. He did not hold the brain as the centre of such functions, and, above all, omitted to include the voice, which is nevertheless one of the most commanding media of communication we have with surrounding objects. He examined the internal functions in a very partial and unsatisfactory manner; he did not point out their co-operation in the great work of nutrition, at which each of them labours as it were in turn; he did not shew the distinctive features that separate generation from all the other functions that relate to the individual only. Accordingly the distinction between external and internal functions was merely produced as points of general consideration in his notes upon nutrition, and in nowise as subjects for classification. Neither did he make use of it in his lectures, of which, however, several manuscripts, revised by himself, are now extant, and wherein he considers: 1st. Osteogeny, which he examined in detail. 2ndly. The action of muscles. 3dly. The action of blood vessels, or circulation, &c. 4thly. Generation. 5thly. The action of the organs of the senses. 6thly. The action of the brain and nerves. 7thly. Digestion. 8thly. Secretion. 9thly. Respiration, &c. From thence it is obvious to remark, that Grimaud, like the preceding authors, confounded all the functions together, instead of referring them to general heads.

In reflecting upon the distinction above mentioned, I soon perceived that it was not only one of those vast and comprehensive views, one of those grand and luminous conceptions, that frequently occur to the man of genius who studies physiology; but that it might be made the basis of a methodical classification. It was necessary to this classification, I remarked, that all functions should be previously referred to two grand classes, the first relating to the individual, the second to the species; that these two classes had no other connections between them but the common bond which unites all the phenomena of living bodies; but that numberless properties distinguished them in such an eminent degree, that it would be impossible to separate them.

These two first classes being accurately determined, and their boundaries fixed by nature, I sought to divide each into orders equally natural: this was no difficult task in the functions relating to the individual. In fact, the general doctrine, both of Aristotle and Buffon, &c., was here evidently admissible, but could not be applied in a general manner; it remained as a matter of importance, carefully to decide the nature and relations of the functions peculiar to each order.

I call *animal life*, that order of functions which connects us with surrounding bodies; signifying thereby, that this order belongs only to animals; that it is superadded in them to those it shares with vegetables; and finally, that it is this excess of functions which forms the line of demarcation between these two parts of the creation. I call organic life, that order which is subordinate to the habitual composition and decomposition of our parts, because this life is common to all organised beings, animals or vegetables; because the only condition required to enjoy it is organisation; and lastly, because it constitutes the limits between organic or inorganic substances, in the same way as animal life constitutes the limits between the two classes that form the first.

Animal life is composed of the actions of the senses, which receive impressions from without of the brain that perceives them, thinks and wills; of the voluntary muscles and larynx which execute its will, and the nerves which are the agents for its transmission. The brain is truly the central organ of this life. Digestion, circulation, respiration, exhalation, absorption, secretion, nutrition, calorification, or production of animal heat, compose organic life, whose principal and central organ is the heart.

I have placed animal heat in this order, because it is evidently, as I shall prove in my chapter on the capillary systems, a function analogous to secretion, exhalation, and nutrition. It is in effect an evolution of combined caloric from the mass of blood; it is, if you will, a secretion, or an exhalation of this fluid, in every part. Until now I had not in my physiological classification assigned it this place, but on re-examining the manner of its production, it will appear that it is entitled to occupy it.

The two orders of the first class being decided, it was easy for me to determine those of the second, which are three; 1st, the sexual functions of the male; 2dly, the sexual functions of the female; 3dly, the functions of the sexual union of the two sexes and its products: these are the three orders.

Such was the classification which I conceived, in commencing my physiological instructions; it evidently differs from all others that have been hitherto adopted in works on physiology; accordingly, a little reflection will suffice to shew its eminent superiority. Let us observe in effect that every class, every order, in this division are possessed of certain generic and characteristic properties, that especially distinguish them, and being applicable to every function of the order, identify them from all the functions of another order. I have elsewhere set down the distinctive attributes of animal and organic life; I have proved that the organs of the one are uniform, and the other irregular; that there is harmony in the functions of the former, and discord in those of the latter; that the latter begins earlier, and ends later, &c. &c.

I have demonstrated that the cerebral nerves especially appertain to animal life; that the nerves of the ganglia depend on the organic life, which is indeed, to my judgment, a remarkable difference, and has induced me to form two distinct systems of nerves, which anatomists had till then reduced to one only. This one system depending on animal life, is composed of the cerebral nerves; the other, depending on organic life, is composed of the nerves of the ganglia, or what is commonly called the great sympathetic.

But it is above all, the vital powers which so strongly characterise both lives; I have shown that one mode of sensibility, and of contractility, belongs to animal life, and another to organic. Consequently, as the vital properties are the cause of functions, it is evident that the distinction of these properties proves that of the two lives to be no assumption, but evinces that nature herself has set their limits, since she has created properties peculiar to each.

It is impossible to conceive a correct idea of the vital properties, as long as the distinction I have drawn be disputed. What controversies have been agitated, and how keenly, on the subject of sensibility. They would never have occurred, if the attributes of animal and organic life had been duly examined and set apart. We shall doubtless cease to confound, as we have done, in one common point of view, the faculty that the heart possesses of feeling the approach of the blood without transmitting its impression, and that with which the skin, nerves, &c. are endued, not only of being conscious of the impression of external bodies, but also of transmitting it to the brain, so that the sensation be perceived.

If we were to comprehend under the common term of irritability, both the motions of the muscles which contract only on the application of stimuli, and those that the brain wills into action, our meaning would be absolutely unintelligible.

A whole century has been wasted on that doubtful question, whether sensibility be the same as contractility, or if the two properties are inseparable from each other. The grounds of either opinion have appeared to be equally tenable. All these disputes are set at final rest by admitting the distinction I have established between vital properties. In fine, 1st, in animal life it is evident that contractility is not a necessary consequence of sensibility; thus external objects act often a long time upon us, and yet the voluntary muscles are unmoved: 2dly, on the other hand, in organic life these two properties are never separated. In involuntary motions of the heart, stomach, intestines, &c. there is first, excitement of organic sensibility, and afterwards, of sensible organic contractility. In the same manner, in those motions necessary to secretion, exhalation, &c., as soon as organic sensibility is excited, insensible organic contractility immediately follows it. It is, consequently, to study them more carefully, and to appreciate them with more nicety, that, in organic life, I separate the two kinds of contractility from sensibility. In the natural state they are inseparable. This explains why the passive sympathies of animal sensibility are totally distinct from those of contractility of the same species, and form two separate classes, whilst the passive sympathies of organic sensibility can never be disunited from those of organic contractilities. Pain affects us by sympathy, and spasms by sympathy are felt distinctly—these two things are almost always separate: on the other hand, sensation and motion, in organic sympathies, are inseparable.

I could, by a thousand other instances, prove that all disputes and differences of opinions, concerning vital properties, proceed solely from the not distinguishing those which preside over the functions of one life, from those that govern the functions of the other.

Let us return to my physiological division; I annex a table of it, which by representing it in the same point of view, will convey a more precise idea thereof. It contains, 1st, the prolegomena or preambles of the science; 2dly, a statement of the functions. In the prolegomena, every thing is referred to two great considerations, on one hand, to organic texture viewed in a general manner, on the other, to life, considered also in its important attributes.

PHYSIOLOGICAL TABLE.

DESCRIPTION OF PHYSIOLOGY.

PROLEGOMENA.

General Considerations on Organic Textures.

- 1st Section.
  - 1. Of organic texture in animals.
  - 2. Single tissues in general.
  - 3. Organs in general.
  - 4. Appendages in general.
- 2nd Section.
  - 1. The properties of tissue.
  - 2. Division of the properties of tissue.
    - Extensibility.
      - 1. By defec of extension
    - Contractility.
      - 2. By con traction.
  - 3. Characteristics of the properties of tissue.

General Considerations upon Life.

- 1st Section.
  - 1. Of life and its functions.
  - 2. Classification of functions.
    - Those relating to the individual.
      - Animal functions.
      - Organic functions.
    - Those relating to the species.
      - Sexual functions of the male sex.
      - Sexual functions of the female sex
      - Functions of the union of sexes and product of that union.
  - 3. The distinctions and connections existing between the two classes o functions.
  - 4. The distinctions and connections existing between the two orders o the first class.
  - 5. The distinctions and connections existing between the three orders o the second class.
- 2nd Section.
  - 1. Vital properties.
  - 2. Division of vital properties.
    - Animal properties.
      - Sensibility.
      - Contractility.
    - Organical properties.
      - Sensibility.
      - Contractility.
        - sensible.
        - insensible.
  - 3. Distinctive characters of vital properties.
  - 4. Causes which modify vital properties.
    - Habit.
    - Sex.
    - Climates.
    - Seasons.
    - Ages, &c. &c. &c.
  - 5. Peculiar differences of vital properties according to each simple tissue in the same subject.
    - What is called peculiar life.
  - 6. General differences of vital properties in different subjects.
    - temperament.
    - passions.
    - character.
  - 7. Sympathies of the vital properties.
  - 8. Division of sympathies.
    - Animal sympathies.
      - Sensibility.
      - Contractility.
    - Organic sympathies.
      - Sensible contractility.
      - Insensible contractility.

FUNCTIONS.

First Class. Functions relating to the Individual.

First Order. Functions of Animal Life.

- 1st Genus. Sensation.
  - 1. Of general sensations or feeling.
    - External.
    - Internal.
  - 2. Particular sensations.
    - Sight.
    - Hearing.
    - Smell.
    - Taste.
    - Touch.
  - 3. Pleasure and pain.
- 2nd Genus. Cerebral Functions
  - 1. Relative to sensations.
    - Perception.
    - Imagination.
    - Memory.
  - 2. Relative to understanding.
    - Attention.
    - Ideas.
    - Judgment.
    - Reasoning, &c.
  - 3. Relative to motions.
    - Will, determined by.
      - Judgment by passions.
        - Of opposition of these two causes.
  - 4. Connections of the cerebral functions with life.
    - Of commotion.
    - Apoplexy, &c.
- 3rd Genus. Locomotion.
  - 1. Immovable attitudes.
    - On the feet—station.
    - Knees.
    - Pelvis.
    - Head, &c. &c.
    - Prostration.
  - 2. Motions.
    - Superior extremity.
      - Propulsion.
      - Repulsion.
      - Abduction.
      - Depression.
      - Elevation, &c.
    - Inferior extremity.
      - Walking.
      - Running.
      - Leaping.
    - Of the chest.
      - Support and lifting up of burthens.
    - Of the whole body.
      - Swimming.
    - Gesticulation, viewed as supplementary to the voice.
      - 1. Of the face.
      - 2. Of the whole of the head.
      - 3. Of the upper limbs.
- 4th Genus. Voice.
  - 1. Brute voice.
    - Muteness.
  - 2. Speech.
    - Stammering.
    - Lisping, &c.
  - 3. Singing.
    - True.
    - False.
  - 4. Declamation.
- 5th Genus. Nervous Transmission.
  - 1. Transmission of sensations to the brain.
    - General.
    - Particular.
  - 2. Transmission of motion.
    - To the organs of locomotion.
    - To the organs of voice.
  - 8. Mode of transmission.

Intermission of the Functions of Animal Life.

- Sleep.
  - 1. Natural.
    - Partial
    - General.
      - Of the senses.
      - Of the brain.—sympathetical sleep.
      - Of the muscles.
  - 2. Unnatural.
  - 3. Dreams and somnambulisms.

SECOND ORDER.

Functions of Organic Life.

- 1st Genus. Digestion.
  - 1. Hunger and thirst.
  - 2. Food.
  - 3. Taking of food.
    - Solids.
    - Fluids.
  - 4. Mastication, mixture of saliva and deglutition.
  - 5. Alteration of the alimentary mass
    - in the œsophagus. Action of the œsophagal juice.
    - in the stomach. Action of the gastric juice.
    - in the small intestines.
      - Action of the bile.
      - Action of the pancreatic juice.
      - Action of the enteric juice.
  - 6. Separation of the nutritive substances from the non nutritive.
  - 7. Absorption of the nutritive substance, passage of the chyle, into
    - the lacteals.
    - the mesenteric glands.
    - the thoracic duct.
    - the blood vessels.
  - 8. Excretion of the non nutritive substance
    - by the peristaltic motion.
    - by the fæces.
    - by flatus.
  - 9. Of vomiting according as it arises
    - from the pharynx and œsophagus.
    - from the stomach.
    - from the small intestines.
    - from the large intestines.
    - from sympathy.

- 2nd Genus. Respiration.
  - 1. Of air.
  - 2. Phœnomena produced by mechanical agents.
    - inspiration.
    - expiration.
  - 3. Chemical phœnomena in respect
    - to air.
    - to blood.
  - 4. Connection of respiration with life, of asphyxias, &c.

- 3rd Genus. Circulation.
  - 1. In general.
    - circulation of red blood.
    - circulation of black blood.
    - action of the heart.
    - action of the arteries.
    - action of the veins.
    - connection of circulation with life....of Syncope, &c.
  - 2. Abdominal.
  - 3. Capillary.
    - general.
    - pulmonary.
      - phœnomena of the motion of the blood.
      - change from red to black.
      - its connection with the general.
      - change of the black to red blood.

- 4th Genus. Exhalation.
  - 1. In general
    - of their agents,
    - of their phenomena.
    - of their alterations.
    - of sympathetic exhalations.
  - 2. Particular exhalations.
    - serous.
    - cellular.
      - of fat.
      - of serosity.
    - synovial.
      - in the sheaths of tendons.
      - in the articulations.
    - medullary.
      - in the middle of long bones.
      - in the extremities of long bones.
      - in the short and flat bones.

- 5th Genus. Absorption.
  - 1. In general.
    - of their agents.
    - of their phenomena.
    - of their alterations.
    - sympathetical absorption.
  - In particular absorptions.
    - serous.
    - cellular.
      - of fat.
      - of serosity.
    - synovial.
      - in the ducts of tendons.
      - in the articulations.
    - medullary.
      - in the middle of long bones.
      - in the extremities of long bones.
      - in the flat and short bones.

- 6th Genus. Secretions.
  - 1. In general.
    - their agents.
    - their phœnomena.
    - their alterations.
    - sympathetic secretions.
  - 2. In particular Secretions.
    - lachrymal.
    - salivary and pancreatic.
    - hepatic.
    - renal.
    - mucous.
    - sebaceous.

- 7th Genus. Nutrition.
  - 1. The double nutritive motion.
  - 2. Composition of organs.
    - nutritive matter considered in assimilation.
      - chyle.
      - blood.
      - organs themselves.
  - 3. Decomposition of organs.
  - 4. Causes that modify nutrition.
  - 5. Of nutrition considered in
    - infancy, ... of increase in growth.
    - youth, ... of increase in bulk.
    - adult age.
    - old age .... decrease.
  - 6. Of natural death.

- 8th Genus. Colorification.
  - 1. Phœnomena of animal heat.
  - 2. Admission of caloric, by
    - respiration.
    - digestion.
    - absorption.
  - 3. Its free state in the blood.
  - 4. Its disengagements in the capillary system.
  - 5. Its expulsion from the body.
  - 6. Of the sympathies of heat and sympathetical heat.

2. CLASS. FUNCTIONS.

Relating to the species.

Parallel of the two sexes. Hermaphrodism.

FIRST ORDER.

Functions peculiar to the male Phenomena of puberty in Man.

- 1st Genus. Production of semen.
  - 1. Secretion in the testis.
  - 2. Abode in the vesicles.
  - 3. Excretion............erection and its phenomena.
  - 4. The semen.
  - 5. Eunuchs.

SECOND ORDER.

Functions peculiar to the female Phenomena of puberty in the woman

- 1st Genus. Menstruation.
  - 1. Its seat.
  - 2. Its periodical nature.
  - 3. Its alteration.
  - 4. Its cessation.
- 2nd Genus. Production of the milk.
  - 1. Secretion in the breast.
    - distinction of this secretion from others.
    - connections between the breast and the womb.
  - 2. Excretion.
    - spontaneous.
    - by suckling.
  - 3. The milk.
- 3rd. Genus. Of the fluids in the woman proper to generation.
  - what these fluids are.
  - their influence.

THIRD ORDER.

Functions relating to the union of both sexes, and the results o that connection.

- 1st Genus. Generation.
  - 1. Copulation.
  - 2. Conception.
    - its phœnomena
      - in the womb.
      - in the tubes and ovaria.
    - hypothesis.
- 2nd Genus. Gestation. relating to
  - 1. The mother.
    - general state of its functions.
    - state of the womb.
  - 2. The fœtus.
    - of its animal life, almost null.
    - of its organical life.
      - functions wanting.
      - activity of assimilation.
    - of monsters.
- 3rd Genus. Parturition and subsequent phœnomena.
  - 1. Causes and process of parturition.
  - 2. Lochia.
  - 3. Phenomena respecting the new born child.
    - developement of its animal life.
    - functions added to the organic life.

Such is the sketch of the general plan I have adopted in my lectures. Such as have attended them will, notwithstanding, find some alterations and additions. We might easily introduce here all the facts that are brought forward in this work, if we were to refer them to one physiclogical classification, instead of distributing them in the anatomical order I have here submitted them.

Although an impassable line of demarcation be drawn between every order of functions, the divisions above must not, nevertheless, be taken in too rigorous a sense. The different orders are, more or less, intimately connected with each other, for instance, in the first class, when one order has ceased to exist, the other is soon destroyed. Thus I have demonstrated elsewhere, that the heart, which is the principal agent of organic life, being once interrupted, the brain, which is the central organ of animal life, is instantly interrupted also, for want of the natural stimulus it receives from it, and its functions are abolished. I have also shown, in the same manner, how the latter viscus, having respiration under its immediate dependance, through the diaphragm and intercostals, which receive the cerebral nerves, has a direct influence on circulation, and therefore the whole organic life ceases when its action is interrupted. Under this head, I have represented respiration as the true bond that connects animal with organic life, and have shewn why fœtuses completely acephalous, and having nothing substituted for the brain, cannot exist out of the uterus, &c. Every thing is linked and woven together in the animal economy. We exist safely within and without, but in two distinct ways, and one life cannot be totally preserved independently of the other. Accordingly, although functions be studied abstractedly, their connexity should be kept steadily in view, when we consider them simultaneously in an active state.

It will be observed that in descriptive anatomy, I have followed a classification almost analogous to that of physiology. The one however differs a little from the other, insomuch as the same organs are frequently subservient to several functions, and certain functions, such as exhalation, nutrition, calorification, have not, properly speaking, distinct and determined organs.

SOCIETY

GENERAL ANATOMY.

SYSTEMS GENERAL TO ALL THE APPENDAGES.

GENERAL CONSIDERATIONS.

The organic systems of the living economy may be divided into two grand classes. The first, generally distributed, and every where met with, not only concur to the formation of all structures, but moreover to that of the other systems, and offer to every organized part a common and uniform basis; they consist of the cellular, arterial, venous, exhaling, absorbent, and nervous systems. The last, on the contrary, situated in some peculiar structures, and foreign to other parts of the œconomy, have a smaller share of the living power, and exist almost distinctly; such as the bony, cartilaginous, tendinous, muscular, mucous, the serous systems, &c. &c.

The first volume of this work will be entirely devoted to the consideration of the general systems, of what I would call the generating systems, if I might be allowed the expression, systems which do not sustain such an important office as to require that every organised part should be possessed of all the six. In effect, some are without arteries or veins, others without nerves; some have very little cellular tissue; but they serve to form the greatest number of parts, and some are always to be observed, while others are deficient. Thus in tendons, cartilages, &c. which are deprived of blood, we find exhalants and absorbents, &c.

In general it appears, that the two systems of exhalants and absorbents are the most universally diffused. Nutrition demands them; this function, in fact, results from a double motion, the one of composition, which conveys substance of nourishment to the organs, the other of decomposition, which conveys it away from the organs. The exhalants are the agents of the first motion, and the absorbents of the second. As every organ must be fed, and as the mechanism of nutrition is every where the same, those systems must necessarily belong to every organ. Next to them, the cellular system is the most generally met with, sometimes in those parts which are destitute of blood vessels, and invariably in those which are provided with them. The arteries and veins rank next in the order of frequency, and pervade almost all parts. It is not uncommon to find no distinct nerves in those parts where they penetrate, as in the fasciæ, fibrous membranes, &c. &c. Lastly, The nervous system is, of all the generative systems, one which the knife of the anatomist detects in the smallest number of organised parts. The serous membranes, the whole fibrous system, cartilaginous, fibro-cartilaginous, and bony systems, are entirely destitute of it.

Being especially intended to form part of the structure of other organs, the generating systems likewise fulfil this office to the advantage of one another: thus, the cellular substance enters into the composition of the nerves, arteries and veins; the arteries and veins on the other hand are seen ramified minutely on the cellular membrane, &c. It is a general intertexture, in which each part gives and receives.

It must be manifest, from what I have stated, that the generative systems, considered in respect to the texture of organs, forming a regular and common basis to all, must precede others in their developement; this is indeed what observation proves to us in a clear and satisfactory manner: whilst the greatest number have scarcely begun to exist in the first months of infancy, these are singularly predominant. The nerves and their centre, which is the brain, the arteries, veins, and their central organ, which is the heart, the cellular tissue, exhalants and absorbents, display this phenomena in a striking manner. It is also strikingly visible in the nervous, arterial, venous, and cellular systems; in the two others, it is proved by the astonishing activity of absorption and exhalation at this time of life.

The idea I have just given of the general systems in the œconomy, will clearly convince us that they act the most important parts in nutrition. They form the nutritive parenchyma of every organ: thus I give the name nutritive parenchyma, to the cellular, vasculous, and nervous canvas, that composes the organ. It is in this very canvas that the nutritive matter is deposited. This matter differing in every organ, has peculiar characteristic features. In the bones, it is the phosphate of lime and gelatin; it is gelatin only, in the cartilages, tendons, &c., fibrine in the muscles, albumen in certain other organs; so that if the nutritive parenchyma of a bone admitted fibrine, it would become a muscle in the shape of a bone; and on the other hand, a muscle would be a bone in a muscular form, if its parenchyma were incrusted with earthy and gelatinous substance. We should be acquainted with the nature of all the living parts, if we could ascertain their nutritive substances, but the major part are yet unknown: it remains to the province of chemistry to enlighten us on this head. All organs are alike in respect to their parenchyma, or at least they bear the strongest analogy to each other. If it were possible to deprive parts of their nutritive matter without injuring the parenchyma, we should detect varieties in forms, in bulk, in the intermixture of the layers of cellular membrane, in the vascular or nervous branches, but not a single shade of difference in their nature or composition.

At an early period of conception, the mucous mass which the fœtus presents, appears to be nothing else but a compound of the general systems. Each organ is as yet endowed with no more than its nutritive parenchyma, which nature has moulded into the shape of the organ about to be developed. As this pulp increases and expands, the nutritive substances penetrate it, and every organ, until then resembling the others in its nature, and forming with them one homogeneous mass, begins to assume a distinct character, and enters into a distinct existence; thus each borrows from the blood the substance fitted to its growth. This addition endues it with the properties of bulk, density, &c., but the increase of the parenchyma, and its tendency to extend itself, are always anterior to it. Whilst inorganic bodies increase by the addition of particles, there exists originally in these an expansive power, from which, length and breadth naturally proceed, and afterwards exhaled substances in the parenchyma, which is extended and enlarged.

By what mechanical process does each organ collect the materials of its nutrition from the common source, the blood? This depends solely upon the quantity of organic sensibility proper to each, which, giving it a disposition for particular substances, exclusive of others, causes it to appropriate them to itself, to impregnate itself with them, and afford them free passage into its vessels, while it contracts and shrinks from contact with others which are foreign to its tissues.

When one of these substances has concurred for a certain time to the formation of the organ, it has then nothing more to do with it, and becomes heterogeneous; its further abode would be prejudicial, and therefore it is absorbed and thrown out by means of the different emunctories; being replaced by a new substance of a similar nature, and furnished by the exhalants. Every organ is then habitually composed, and decomposed: therefore this composition and decomposition vary in proportion. The preponderance of the former over the latter constitutes bulk. The due and steady equipoise of the two, ensures the stationary and settled state of the body, which is exemplified in the adult. When the activity of the second supersedes that of the first, emaciation and debility are infallible consequences.

Such is in substance the manner in which the general theory of nutrition can only be understood, a theory which I shall unfold at greater length in my physiology, and on which I shall dwell a few moments longer, to demonstrate that it is a system not gratuitously imagined, but that it absolutely rests upon the laws of the animal economy, and its organic phenomena. Accordingly, I think that this assertion will be fully demonstrated, if I prove, 1st. The uniformity of the parenchyma of nutrition; 2dly. The variety of nutritive substances; 3dly. The faculty that the nutritive parenchyma enjoys of appropriating to itself, according to its degree of organic sensibility, such and such nutritive substances exclusively of others, and subsequently rejecting that substance, and assimilating another. Such are, in fact, the fundamental principles of this theory.

I assert in the first place, that the parenchyma of nutrition is the same in all organs, and that it is an assemblage of red vessels, exhalants, absorbents, cellular membrane and nerves. These are the proofs; 1st. These different species of organs are united in every other part, as I have already stated; anatomy detects them everywhere, between every fibre, every layer, and in every point as it were, they are indeed common organs.

2dly. When we deprive organs of their respective nutritive substances, the bones for example, of their phosphate of lime by means of acids, and the gluten, by those of concoction, a residue is left evidently of vessels and cellular membrane. 3dly. It is certain that the process of consolidation, in divided parts, is the same as that of their natural nutrition. Thus in the healing of wounds, the parenchyma of nutrition begins first to display itself, and is everywhere the same; it shews itself every where in the form of granulated points, which are cellular and vascular, and have the same character and aspect, whether they shoot from a bone or cartilage, or whether they are formed in muscle, ligament, or the skin, &c. All breaches of substance resemble each other, as organs do, with regard to this common parenchyma: that which constitutes the difference between them, as between the organs, is the nutritive substance, which interposes itself in its tissue, and varies according to the part affected: thus the phosphate of lime encrusting the granulations of bones, gives a different nature to the callus from that of muscular wounds, which are united by the exhalation of fibrine in the granulations that are produced on the divided surfaces, &c. 4thly. The mucous substance, which forms the body of the embryo, appears to be nothing but cellular, or mucous tissue, as Bordeu calls it, a texture redundant with blood vessels and nerves. In fine, when organs are developed in this mucous substance, it is still visible for a certain time in their interstices, and presents the same aspect as the body of the embryo in the early stage of utero-gestation; it consolidates by degrees—fills with cells and puts on the form of cellular membrane: from whence we may presume, that in this mucous state of the embryo the parenchyma of the nutrition of organs exists only, and as this parenchyma is the same in all, it is evident that the mass of the embryo must appear homogeneous in its nature. Nutrition commences when each individual parenchyma appropriates to itself its peculiar substance, and all similitude of nature ceases. It is not difficult after these considerations, to perceive the uniformity of the nutritive parenchyma, as also its cellular, vascular, and, in some cases, nervous texture.

I am well aware that this common parenchyma of nutrition which has been admitted, must itself be provided with the means of nutrition, and that consequently we must ascend still higher; but truth in physiology must be sought, and can be found only in secondary effects; in them we seek the lights of experience and of facts, and beyond them we meet only with the false illusions imagination.

After having demonstrated that every organ is alike in respect to the common parenchyma of nutrition, it is needless to prove that they differ in the substances therein deposited. Animal chemistry has, within a few years, thrown so much light on this point of doctrine, that it is idle to dwell longer on it, or to attempt farther refutation of what has been written respecting the identity of the nutritive juices.

Finally, it is easy to comprehend in what way each parenchyma of nutrition appropriates to itself, according to its degree of organic sensibility, the nutritive substances which are suited to it, and which the tide of circulation conveys to it. This is not a phenomenon peculiar to nutrition, it is observable in every act of organic economy. Accordingly, secretions operate only in virtue of a determinate degree of sensibility, which adapting each gland to the fluid it secretes, enables it to receive that fluid and reject others; thus, the red part of the blood does not commonly penetrate into the exhalants, because it is the serous part only that has any relation with the degree of their organic sensibility: thus substances conveyed through the intestines will never enter into the ductus choledocus, or pancreaticus, although the diameter of these ducts exceed that of their globules: thus the cantharides act exclusively on the sensibility of the kidneys, and mercury on that of the salivary organs, &c. &c. From these considerations, it is plainly seen, that the process by which the parenchyma of nutrition appropriates to itself the nutritive substances, is not an insulated phenomenon, but the consequence of a general law of organic sensibility. But why does this property display almost as many different degrees as there are organs existing in the economy? Why do these different degrees establish relations so distinct between the organs and substances that they repel? Here let us pause, and content ourselves with having proved this fact by innumerable examples, without seeking to divine the cause. On this head we can only offer conjectures.

These few notions respecting nutritive phenomena, although indirectly connected with the subject matter of this volume, are not here misplaced, because in these phenomena, the generative systems which we are about to study enact the most remarkable part, and because, we shall have frequent occasion to mention them, in examining the developement of organs, a subject which authors have but indifferently examined, and on which Haller, the most judicious and minute of physiologists has glanced but slightly, although it be peculiarly deserving of the study of physicians, and those above all, who would examine diseases, with particular regard to the influence that the various stages of life exert over them.

CELLULAR SYSTEM.

THIS system, that many even now describe under the name of the corpus cribrosum, mucous texture, &c., is an assemblage of filaments and of whitish layers, soft, interlaced, and intermixed in a thousand different ways, and leaving between them certain interstices which communicate together; others are more or less irregular, and serve for the reception of fat or serum. Immediately surrounding the organs, the different parts of this system form at the same time both the bond that unites them, and the medium that separates them. They extend into the substance of these organs themselves, and contribute largely to their structure.

The considerable extent of this system, which although diffused every where, is every where continuous, the multitude of organs it surrounds, the innumerable relations it holds, do not allow me to view it under a general aspect, as has been hitherto done, it is necessary to identify the different points of view in which it may offer itself before we can furnish a complete picture of it.

I shall then waive the consideration of the general system which is formed by the continuity of its different parts, and view it only with relation to the organs it surrounds, or contributes to form. I shall afterwards examine it, independently of these organs, in the spaces between which it is universally found. In short, its organisation, properties, connections with the other systems, and developement, will be the object of my researches.

ARTICLE THE FIRST.

The Cellular System examined in respect to the Organs.

The cellular system, considered distinctly, and with reference to all other organs of the living economy, presents two striking features; 1st. It forms an envelope or outward limit to the organs; 2dly. It enters freely into the structure of each, and forms one of the essential bases of the same structure.

Of the Cellular System exterior to every Organ.

The various conformation of the several organs, produces two very distinct modifications in their connection with the cellular tissue that surrounds them. Sometimes, indeed, it only adheres to one of their surfaces, sometimes it envelopes them entirely. The former peculiarity of the structure exists when these organs have one side free and the other adherent, as the skin for instance; the second, which is more general, is found when it is connected universally with the adjacent parts. Let us separately consider these two cases.

The Cellular System, connecting the Organs only on one side.

There are three membraneous organs, which are free on one side, and are clothed with cellular tissue on the other: these organs are the skin, the serous and mucous membranes. We may likewise mention that which lines the outside of arteries, veins, absorbents, excretories, which have none internally. As this tissue has also a place in the formation of these vessels, most authors examine it in treating of this subject. I judge it preferable to enter into a general consideration of the different parts of the cellular membrane.

Subcutaneous Cellular Tissue.

Besides the chorion, which is abundantly furnished, as we shall see, with cellular tissue, and which anatomists suppose is formed by a peculiar condensation of this tissue, the skin universally exhibits, wherever you examine it, a subjacent cellular layer, the quantity and density of which varies in different parts of the body.

Along the median line, this tissue seems closer and more strictly adherent to the skin than in many other parts. This is easily ascertained by dissection, in the middle of the nose, lips, sternum, linea alba, about the spinous processes of the vertebra and sacrum, the posterior cervical ligament, &c. The strength of this adhesion occasions a distinct separation between the two great divisions, of the sub-cutaneous cellular tissue in each half of the body, a separation which I have borne repeated witness to, in my experiments on emphysema. On inflating the integuments of one side of the body with moderate force, I observed in many subjects that the air did not penetrate beyond the median line, so that on one side there was general distention, and on the other the usually collapsed state of the cells. It was often necessary to increase the strength of the effort considerably before I could overcome the resistance, and render the emphysema general. We are not however always successful in producing this phenomenon, while, at other times, general inflation is easily effected, particularly if we blow up the cellular substance above the neck, which is loose anteriorly, as well as at the median line and side.

In consequence of the thickness of the sub-cutaneous cellular membrane being increased at the median line, the body, according to an assertion of Bordeu, in which I concur, is divided into two equal vertical halves. In no other parts, excepting the skin, have we any vestige of such a separation. I have demonstrated elsewhere, in one of my works, that the division of the body into two uniform halves, is a general attribute of the organs of animal life, an attribute that distinguishes them from those of internal life, which are remarkable for their irregularity : it is in this light, and not in that which Bordeu has placed it, and which runs manifestly counter to anatomical facts, that the median line should be viewed.

In other parts of the body, the sub-cutaneous cellular tissue varies considerably in its texture. 1st. The density of this texture is remarkable in the hairy scalp of the skull, which, on this account is not easily separated from the subjacent fascia and muscles. Such as are familiar with the dissection of apoplectic subjects, are well aware that the head and neck are in an emphysermatous state. I have already seen this phenomenon in four bodies. The face is accordingly much inflated, the hairy scalp not at all, or at least in a very small degree. 2dly. In the face the sub-cutaneous tissue is very loose, and extremely abundant. 3dly. It is equally loose in almost all parts of the trunk, and accommodates itself easily to the motions of its wide and powerful muscles. 4thly. In the extremities, the sub-cutaneous cellular tissue, situated between the apounerosis and the skin, observes almost in every part an equal proportion and laxity. It is only in the palm of the hand, and the sole of the foot, that its texture, increasing in density, there is stronger adhesion of the fascia to the skin, an arrangement highly favourable to the uses of these two parts, which must therefore mould themselves to bodies, seize, grasp, and hold them. This closeness of texture, is a substantial reason why they do not swell like other parts in dropsies, and preserve their natural appearance, although the rest of the sub-cutaneous tissue has been filled for a considerable period with fluid. I saw two subjects affected with elephanteasis, who had the whole of the integuments and the subjacent tissue of the inferior extremities enormously swollen, except in the sole of the foot; the contrast that this part exhibited in its natural state, with the back swelled to an astonishing bulk, gave the foot that peculiar aspect which has been noticed by authors.

The texture of the sub-cutaneous cellular membrane is dense about the capsular ligaments, for which reason the adhesion of the skin is stronger: hence those contractions we observe at these parts in the extremities of infants, very little fat being admitted into the condensed cells.

The sub-cutaneous cellular tissue fulfils many purposes. From it the skin borrows the great freedom of motion it enjoys over the organ it covers, and which is particularly observable in the muscular action of the extremities and trunk, in the shocks that the skin receives from outward bodies, in the different tumors that attain any considerable size, as in sarcocele, which is frequently covered at the expence of the integuments of the penis, the lower part of the abdomen and thigh;

the skin is in this case drawn down from its place, and may be said to undergo absolute locomotion.

It is also to this tissue that organs subjacent to the skin partly owe the facility with which they move, in those powerful contractions of which they are capable. Fat, which is contained in great abundance in its cells, contributes to secure the subjacent parts from the keen effects of atmospheric air. It is well known that this fluid is secreted in greater quantity in winter than in summer; that it is found in considerable proportion beneath the skin of such animals as inhabit cold climates: that emaciation, a natural result of severe disease, renders the body peculiarly susceptible of cold, &c.

The effusion of serum appears to take place in the sub-cutaneous tissue in a much larger proportion than in other parts; it has a particular tendency to accumulate there, in consequence, without doubt, of the excessive laxity of this membrane. If we compare the quantity of fluid that fills this tissue in an anasarcas limb, with that which occupies the space between the muscles and the interstices between the fibres of different subjacent organs, we shall find that there is no comparison between the two, and that the size of the limb is proportionally more encreased by the distention of the sub-cutaneous part of the cellular tissue than of that more deeply seated. To see this clearly, we must compare an inferior extremity in a sound state, and stript of its integument and subjacent tissue, with a dropsical limb prepared in the same way, having like the former no other covering but the fascia, and we shall find that the difference between them is but very slight.

Sub-mucous Cellular Tissue.

The mucous membranes have the same connections with the cellular tissue as the skin, from which they are continued, and with which they have, as we shall perceive, the utmost analogy of structure. There is then a sub-mucous as well as a sub-cutaneous tissue. But this essential difference exists between them, that the texture of the first is infinitely denser and closer than that of the second, and consequently the connection of the mucous system with the neighbouring parts is much more considerable than that of the cutaneous system. To this difference must we refer: 1st. The difficulty of dissecting the mucous membranes, and separating them distinctly from the subjacent parts: 2dly. The absolute impossibility in experiments, of inflating the sub-mucous tissue, while all others are easily filled with air: 3dly. The constant absence of air in this tissue, in cases of even extensive natural emphysema: 4thly. Also the entire deficiency of serum in the sub-mucous cells, in the worst cases of anasarca, an essential phenomenon in respect to hollow organs, whose obliteration would soon take place if in dropsy the sub-mucous tissue admitted of the same degree of distension as the sub-cutaneous.

Is it to the difference of texture in these two portions of the cellular system in general, that we must attribute the greater frequency of phlegmon observed in the latter than the former tissue, or does it proceed from the latter being less exposed to the action of surrounding bodies? I should suppose both may contribute to it in like degree. I am disposed to ascribe it the more forcibly to the first, as the throat, which exceeds all other organs in the looseness of its sub-mucous tissue, (and particularly in the neighbourhood of the tonsils) presents the greatest degree of liability to phlegmonous inflammation. To conclude, it is the firm and dense texture of this tissue that enables it to give at once origin and termination to the numerous fleshy fibres which constitute the muscular coats of the stomach, bladder, and intestines, and to fulfil the same office with them that the tendons do with the muscles of animal life.

Sub-serous Cellular Tissue.

We find under almost every part of the serous system, as well as the two preceding tissues, a cellular layer, generally very abundant and very loose, as may easily be ascertained by examining the peritoneum, pleura, tunica, vaginalis, testis, pericardium, &c. This exuberance of cellular tissue is especially intended to yield to the different changes that membranes undergo, to their dilatation, contraction, and their displacement under certain conditions; for instance, we shall find the peritoneum sometimes belonging to the onsentum and sometimes to the stomach, according as the last viscus is full or empty. In these cases it is necessary that the neighbouring tissue should be extremely loose; to this must be attributed the facility with which the sub-serous tissue in dropsies fills with water, and in emphysema with air. Next to the sub-cutaneous tissue there is no part of the living economy more readily disposed to these unnatural secretions.

At particular parts however, the serous membranes adhere strongly to the neighbouring organs. The pericardium in its two layers, the synovial membrane with the cartilages and fibrous capsules, the tunica arachnoides with the dura-mater, afford us examples of this arrangement, that constitutes when the adhesion is with a fibrous membrane, the sero-fibrous membrane.

Cellular Tissue external to Arteries.

Around the different arteries, we find a strong dense elastic layer, which at first glance appears to be one of its proper coats, but evidently belongs to the cellular system, and bears the utmost analogy to the texture subjacent to the mucous membranes. It is never the seat of serous effusions, nor does fat ever accumulate there; it is rarely attacked by inflammation; it arises almost imperceptibly from the neighbouring cellular tissue, which becomes condensed and is so interlaced, that it may be wholly detached, and forms a sheath or canal corresponding to that of the artery it surrounds and supports. Are there any arterial fibres interwoven with this tissue as muscular fibres of the stomach and intestines are interwoven with the sub-mucous membrane? I do not believe it; for if this were the case, we should not be able to detach this cellular sheath surrounding the arteries so easily. Arterial fibres appear to form complete circles, and consequently have not their extremities inserted like the muscular fibres. Some of these fibres, nevertheless, remain still adherent to the deepest layer of cellular membrane when this is removed, as appears by their peculiar direction and yellowish hue.

Cellular Tissue external to Veins.

Veins are provided with an external covering analogous to that of arteries, but in general much less dense and firm. It does not separate so easily in an entire sheath as it does in the arteries. It contains no adipose substance, secretes little serum, suffers no distension in dropsies, and in all diseases preserves its original state. When this outward tissue is removed layer by layer from the parieties of the veins, one may perceive that it is there dryer than in other parts. I have often been disposed to think it does not, like that of the arteries, excretories, and mucous surfaces, exhale that albuminous fluid which lubricates the other parts of the cellular system. We shall find that its organization is distinct in nature, and forms a manifest exception in this system.

In examining the cellular sheath of veins and arteries, and particularly the latter, we must take care not to confound its filaments with the numerous nervous threads which are supplied from the ganglia, and form a plexus around them. The cellular tissue is whiter, and the nerves more of a greyish hue; an appearance which is particularly striking after a few days maceration.

I can say nothing of the tissue external to the absorbents, they are, doubtless, furnished with it like the veins; but such is the exquisite delicacy of these vessels, that we can avouch nothing concerning them that is supported by experience and dissection.

Cellular Tissue external to the Excretory Ducts.

The ducts of the salivary glands, kidneys, testicles, liver and pancreas, &c. are clearly enveloped in membrane analogous to the preceding, but perfectly distinct from the adjacent tissue, and which enters into it without partaking of its properties. It forms a distinct body, in density, form, and texture. The filaments of which it is composed being separated by no interstitial fluid, remain closely applied to one another, so that collectively they form a membrane resembling a sheath that may easily be removed, like that surrounding the arteries; it is in effect thicker than in the venous system.

Of the Cellular System considered in respect to the Organs it completely involves.

With the exception of the organs just mentioned, all parts of the body are completely surrounded by a covering of cellular substance, more or less extensive, forming, as Bordeu has so happily expressed it, a peculiar atmosphere for each—an atmosphere in which they are entirely immerged, that insulates them from other organs, and destroys to a certain degree such communications as have a tendency to connect them intimately, or to identify their existence one with another, provided they were brought into immediate apposition.

The serous vapour that habitually penetrates the cellular atmosphere of every organ, the adipose substance, that is there floating in more or less abundance, also powerfully contribute to make their respective shares of life distinct. They form to the several organs an intermediate substance, which, in its nature as a fluid, enjoys less of the living power than them—is as it were thus placed beneath their level, and has consequently a tendency to break, in a certain degree, the vital communications that subsist between them. The essential difference between the peculiar life of the cellular tissue and that of the other organs, enables it to perform a separate duty by itself, as a solid, and independent of the fluid it contains.

To the absolute separation of life in the different organs, through the means of the surrounding cellular tissue, we must partly refer the absolute distinctness of diseases, or, more properly, the alteration of life. Every day we see a diseased organ contiguous to a healthy one, but no derangement in the structure of the latter. Do we not find the pleura sound, and the lungs beneath covered with tubercles and ulcers; the peritoneum inflamed throughout all its extent, while the intestines, stomach, liver and spleen are nevertheless in a natural state; the mucous membranes affected with disease, and the bordering parts they line without a trace of it; the skin suffering under numberless eruptions, and the sub-cutaneous organs perfectly free; the tunica arachnoides suppurated, and the brain in structure uninjured, besides a thousand other facts of the same kind—these are phenomena that the dead body exhibits constantly.

Need I call to mind the various tumours that are developed in the very heart of the vital organs without impairing them, the numberless excrescences that vegetate beside them without their partaking in them? Let us for a moment dissect a muscle beneath a frightful suppurating wound in the skin, we shall not find, at least in the majority of cases, any change in its structure or appearance, the skin alone is diseased. Undoubtedly the difference of vitality between two adjacent organs, is the substantial cause of the distinct nature of diseases, but the cellular atmosphere that defends them, is another and not less so. Thus, whenever one organ sends processes or parts of its own structure to another, it communicates its diseases much more readily than if it were separated from it by a thick cellular covering: for instance, the affections of the periosteum and of the bone are soon blended together, as we well know.

We must not, however, carry this idea too far, in considering the cellular atmosphere as it has been called, as an insurmountable barrier to diseases. Practice would often greviously belie it, in shewing diseases passing from an organ to the surrounding tissue, and from that tissue to the neighbouring organ; so that sometimes we find it an obstacle, at others the medium of their propagation. The atmosphere it forms may, and does, often become loaded with the emanations arising from the organ, or, to speak in language more strictly medical and physiological, the vital properties of one organ being once changed, those of the surrounding tissue will frequently be altered by communication, and gradually that of the neighbouring organs. The medium of that influence which organs exert one over the other, must be carefully distinguished from sympathies, wherein one part being diseased, another may be affected without the intermediate organs being disturbed in functions. In this case we find in the propagation of diseases, the same order as exists in the juxta-position of the organs.

A considerable number of local affections affords us instances of that state of relation that exists between the investing membrane, and in process of time, the contiguous organs and a diseased organ. In phlegmon, we observe, more or less tumefaction around the red and inflamed part. Rheumatism that affects the tendinous expansions about the wrist, fingers, &c. excites a painful swelling in these parts: considerable enlargement of the knee is almost always the result of these diseases of the joint, which are confined to the ligaments, &c. Many tumours have a diseased atmosphere around them, more or less extended, which exists always in the cellular membrane, and even constantly partakes of the nature of the tumour. If it be acute, as in phlegmon, it is a mere swelling that will almost totally disappear at the moment of death, as I have frequently remarked in the dead body, where I have found a part that had been inflamed and enlarged during life, almost restored to its natural bulk at the moment of death. If the tumour be chronic, we shall find induration more or less striking extending its ravages often far and wide to those parts surrounding the diseased organ, as is seen in cases of cancer.

This atmosphere of disease is not only developed around the diseased organ, but also involves the neighbouring parts. Inflammation of the pleura extends itself to the lungs, that of the convex surface of the liver to the diaphragm. Pericarditis, by its influence on the fleshy fibres of the heart, excites in that organ the irregular motions of an intermittent pulse. Peritonitis, at first exclusively confined to the peritoneum, ultimately produces disease of the subjacent intestines, when it degenerates into a chronic affection, and this is what constitutes chronic enteritis, &c.

It is to be remarked, however, that simple contiguity often suffices of itself to communicate disease without the intervention of cellular tissue, a carious tooth, for instance, decays the neighbouring one; the inflamed portion of a serous membrane, in contact with sound parts, will quickly inflame them ; thus it happens, that when inflammation has lasted for some time, the whole surface is found diseased, though pains have only been referred to one spot.

I am convinced that the cellular atmosphere of organs, is not only the medium of propagating diseases, but also of communicating the beneficial effects of medicines. How is it that in rheumatism a blister applied to a distant part is found frequently ineffectual, whilst placed on the integuments covering the diseased muscle or tendon it will produce almost a sudden effect ? How is it that stimulating cataplasms applied to the scrotum, frequently exert a decided influence over a diseased testicle, although there exists no vital connection between the skin and this gland ?—why again do many other substances, applied also to the skin, act powerfully on the subjacent parts ? Assuredly it is the cellular membrane that is the means of communication, as also in various applications made to the mucous membranes. Gargles are found useful in inflammation of the tonsils, an emollient injection reduces that of the peritoneum, &c. Thus these means are not directly applied to the diseased organ, but their effects are transmitted by the sub-mucous tissue. Notwithstanding the advantages of such applications, either on the surface or mucous membranes, their effects on organs of a different nature and such as are subjacent to these surfaces, have been too much exaggerated. Experience proves but too often that the latter may be excited or irritated in some way without prejudice to the contiguous organ, because the vitality of that organ and theirs bears no resemblance nor correspondence, and one is insensible to the affections of the other, although the parts are contiguous. Who does not know the little efficacy that dwells in emollient and discutient applications recommended for tumours in the breast, in the glands of the groin, arm-pit, &c.?—who does not know that they will as often subside without our applications as with them? Formerly, whenever a tumour made its appearance under the skin, though it were seated in the abdominal viscera themselves, and separated from the integuments by different and even opposite tissues, medical men were wont to cover it with a cataplasm. In modern surgery we recognize the inutility of such applications, and merely avail ourselves of such as act on the organs that are most subcutaneous. We shall one day perhaps be sufficiently acquainted with the properties and actions of each organ, to be enabled to judge when the cellular tissue may be made the medium of communicating the effects of medicines between two contiguous organs differing in structure and properties, and when it is the barrier where the communication of these effects receives a check. Till then we shall wander frequently in doubt and darkness. An application to the skin will often act by sympathy on distant organs, whilst it has no effect on the surrounding ones with which it has no relation: for instance, a bath will check spasmodic vomiting, without tranquillizing in any degree those pains that have their immediate seats in the sub-cutaneous organs in general.

The vital powers of an organized part generally undergo a specific change, and its disorders consequent are produced in three distinct ways; 1st, by direct irritation, as when the tunica conjunctive is inflamed by exposure to cold air, or air loaded with moisture and exhalations; 2ndly, by sympathy, as when one eye being diseased the other has its structure involved in the same affection without any apparent essential cause; 3rdly, by cellular communications, as in carious bones, where the integuments appear of a dull livid hue, and swoln.

Why is the cellular membrane, in some instances, an agent that nature employs to defend the organs from the influence of that which is diseased, whilst in others, it serves to propagate disease? Let us confine ourselves, on this point, to the evidence of facts; the enquiry of causes is merely matter of conjecture.

The cellular atmosphere of the organ is not only connected with the immediate phenomena of its vitality, but also with the different motions this organ performs: consequently, it is more abundant as these motions are more extensive. This observation is verified, by comparing the cellular substance, which is found in considerable masses about the heart, the large arterial vessels, eye, womb, bladder, the large joints, as in the axilla, &c., to that external to tendons, fasciæ, bones, &c., this is generally very rare. The extension and compression of which its cells admit, gives it the power of adapting itself to the extensive motions of the organs, particularly to those of dilatation and contraction, that are facilitated besides by the fluids it contains. Those organs, on whose external surface very little cellular substance is discoverable, and which execute many motions, as the stomach, intestines, and brain, &c., are furnished with serous membranes, for the supply of this defect. These membranes, and the cellular tissue, are, in fact, the two great and sole means that nature has provided organs with, for the facility of their motions.

There are certain organised parts possessing scarcely any motion, and surrounded nevertheless with a large quantity of cellular substance: we see a striking instance of this in the kidneys. The testis, and its membranes, are also buried in an accumulation of it; the thyroid gland is plentifully supplied therewith, as also the pancreas and salivary glands, which are separated by the limits it forms from the neighbouring organs. In general, almost all immoveable parts, notwithstanding the unimportance of their functions, when they are not divided from the others by the serous membranes, as the thoracic and abdominal viscera for the most part are, are every where bounded by a cellular tissue of some thickness.

SECTION II.

Of the Cellular System lining the Organs.

After having given a covering to the organs, the cellular tissue enters every where into their intimate structure, and forms one of their principal elements. In those viscera which are composed of several parts, these parts are united together by it: thus, in the stomach, intestines, bladder, &c., the different layers of which it is composed separate the serous, muscular, and mucous membranes of the several hollow organs. It sends a multitude of processes into the structure of the lungs, between the serous membrane and their parenchyma, between this and the bronchia, between the bronchia and mucous surface.

In the large organs, the cellular tissue first attends and surrounds throughout their whole course, the vascular and nervous ramifications which are found in their composition; and afterwards unites the different homogenous parts that compose each. Every muscular fasciculus, or fibre, or nervous filament, every portion of fascia or ligament, every glandular particle, &c. are enclosed in a sheath and peculiar cellular texture, which, in respect to these parts, fulfils the same purpose as the larger envelope we have mentioned does in respect to the whole organ. Thus, the life of each fibre is insulated by this membrane, which, like that of the entire organ, forms round it a kind of atmosphere calculated to secure and protect it, and may be notwithstanding accessory, like the general membrane, and even more so, on account of the closer juxtaposition, to the communicating diseases from one fibre to another. The motion of each of these fibres is astonishingly promoted by the cellular membrane: accordingly, these organs which, like muscles, have an apparent motion in their several parts, abstractedly considered, possess much more within than those which, like tendons, ligaments, glands, have no sensible motion but that which is communicated to them.

The cellular tissue lining each organ, assumes but little of the character of vitality which distinguishes the organ; it preserves almost all its general properties; it is in the structure of the different parts a material that unites the others without assimilating them. It is void of sensibility in the nerve, of contractility in the muscle, and has no concern with secretion in the gland. Thus it is frequently affected without deranging the organ, of which it constitutes a part. In many organic diseases of the liver, we meet with steatomatous tumours that give this organ a peculiar irregular form, and which occupying only the cellular tissue, do no prejudice to the glandular tissue, which as usual secretes the bile, whose chemical composition is unchanged. It is a very singular phenomenon, that there is often considerable derangement of structure without any disturbance in the secretion of bile. We may compare it to changes not less remarkable, that the lungs are subject to in consumption where respiration, despite the violence of disease, is carried on with almost the same regularity as in a state of health.

The tissue of certain organs is so very close, that the cellular tissue can hardly be discerned; some authors even have been inclined to deny its existence. In many of these organs however it may be made perfectly distinct by maceration, which insensibly softens and separates their fibres, as in the tendons and fibrous membranes. Boiling deprives some of their nutritious matter, gelatine for instance, and leaves a membranous residue, which is evidently cellular. In all, even bones and cartilages, &c. granulation, the production of which, as we shall find, is specifically of a cellular nature, proves the existence of this internal tissue, of which there are so many processes. It is the same in mollities ossium, and fungous tumours of other organs, diseases in which this tissue becomes very apparent, because the organ is thereby deprived of its closeness of texture, and assumes one of a looser and more spongy sort, that allows the cellular substance found in the interval of its fibres to be exposed with greater precision and delicacy by the knife.

ARTICLE II.

The Cellular System considered independently of the Organs.

After having considered the cellular system, in connection with the organs, we shall pass over those parts it surrounds and penetrates, and investigate it merely as a continuous body, extending in every direction, and filling up the spaces between the organs, being analogous, in this point of view, to almost every other primitive system. Let us follow it in the head, trunk, and extremity.

SECTION I.

Of the Cellular System in the Head.

The cranium and face differ exceedingly in structure with regard to the cellular tissue; in the former it is very scarce, and in the latter, abundant in proportion.

Cellular Tissue of the Cranium.

The contents of the cranium are but scantily supplied with this tissue, which is scarcely any where apparent. If, however, we raise the arachnoid membrane in those parts where the vessels dip into the substance of the brain, and those also where the nerves arise, we shall detect a small quantity of it, remarkable for its excessive fineness and transparency. The pia-mater is chiefly composed of this tissue, which appears to be continuous with that of the brain. It is very difficult notwithstanding to demonstrate this fact, although we macerate the brain; indeed it is only visible in fungous tumours, and then, by no means clearly ascertained.

The communications of the cellular tissue within the cranium are very numerous.

1st. Anteriorly, the membrane passes into the orbit by the foramen opticum and the fissura sphenoïdalis: from thence the redness and suffusion of the eye in cases of phrenitis, whose influence is propagated by means of such communications, as well as by the continuity of the membranes. It enters the nostrils by the foraminula cribrosa, &c., which explains the sense of weight and head-ache which is experienced in coryza, &c.

2ndly. Inferiorly, the numerous foramina in the basis of the scull connect the cellular tissue of the brain with that of the face, and particularly with the top of the pharynx and fossa under the zygoma, &c. In many cases where angina is attended with pain, with weight in the head, oppression, &c., I am convinced these communications act an essential part, notwithstanding in many instances these sensations are purely sympathetic.

3dly. Superiorly and posteriorly, the cellular tissue of the brain connects itself with that of the corresponding parts of the head, through the numerous, but minute openings of the sutures; it attends the vessels which proceed from the dura mater to the pericranium, and perhaps sometimes becomes the medium of the communications so frequently noticed between these membranes when either is inflamed: hence the sudden affection of the dura mater and tunica arachnoides, occasioned by the coup de soleil, &c. Although more abundant without the cranium, the cellular tissue is not however found there in any great quantity, as the muscles in that part are few and delicate of fibre. Its communications with the face are evident, particularly anteriorly on the forehead; accordingly, when the scull is afflicted with erysipela, nothing is more common than to see the eyelids receiving part of the pus which had formed above, and frequently in such a quantity as to cause considerable tumefaction in these soft moveable curtains. Serum and blood is also effused there by similar means, &c. Posteriorly and laterally, the connexions of the cellular tissue of the cranium are free and striking.

Cellular Tissue of the Face.

It is very abundant in all parts: it fills the orbits, lines the excavation of the cheek, which is bounded by the buccinator, the masseter, the os zygomaticum and the os malæ, and clothes all the neighbouring parts about the tongue. It occurs in very small proportion about the fossæ nasales and their cavity, which is lined by a mucous membrane, adhering almost immediately to the bone.

The cellular tissue of the face contributes to the beauty and harmony of the physiognomy, whose features, if deprived of the secretion that fills it, would disclose the harsh and irregular lines of the muscles under the skin. In an opposite state, it exhibits a kind of swelling void of grace: the middle state is the most advantageous to the face. This membrane has no concern with the various expressions the features may display; muscles are exclusively intrusted with that office. Thus the various passions are expressed in like manner in the face whether it be full or thin. In the latter, however, their influence is strongly marked, in consequence of the greater number of wrinkles that are formed by the contraction of the muscles.

The cellular tissue about the face varies with regard to quantity in certain individuals. It is well known that corpulent subjects are often remarkable for the thinness of the face. This I ascertained, by dissection in such subjects, arose from the scantiness of the cellular tissue in that part. We observe in other individuals, that the fulness and plumpness of the countenance is curiously contrasted with the slenderness and diminished bulk of the whole person, owing doubtless to the reverse of the reason which I have assigned for the first, although, I confess, its grounds may be liable to objection.

To the increased proportion of this tissue rather than to the expansion of muscles, must be ascribed the peculiar thickness, which we remark in various parts of the face in different nations, about the lips and alæ nasi of negroes, &c. The same observation applies to the varieties that occur in the thickness of the lip.

The chief communications between the cellular tissue of the face and the neck are effected by the sub-cutaneous portion of this membrane, by that which attends the vessels in their tract, and particularly in the triangular space, at the upper part of which the parotid gland is situated. Thus in abscesses of the cheeks, sinuses often extend to the neck. In emphysema, when the air proceeds from the thorax, after the neck is inflated, it rushes to the face principally by the sides. There exist other free communications of cellular tissue, between the face and the neck, in the spaces of the muscles that are attached to the root of the tongue.

SECTION II.

Cellular System of the Trunk.

Its quantity is subject to infinite modifications in different parts, whether it be the spine, neck, thorax, abdomen or pelvis.

The Vertebral Cellular Tissue.

I apply this term to the cellular tissue which is found about the spine, and that also which the vertebral canal contains. There is very little in the cavity of the canal. It produces however several filaments that accompany the vessels and help to form the pia mater, between the tunica arachnoides and medulla spinalis, between the spinal nerves and the sheaths formed by this membrane that attend them. It does not exist between the tunica arachnoides and the dura mater. Under this membrane, and between it and the vertebral channel, as well as in certain parts where it does not adhere, we find it in larger quantity, especially in the lower division of the canal, where it is extremely loose, and secretes a fluid frequently of a reddish hue.

The spine externally is clothed behind with a mass of muscle, but very little cellular tissue. Abscesses of this part are accordingly rare, and not so liable to produce sinuses as elsewhere, owing to the muscles attached to the processes of the vertebræ being closely compressed together, and the cellular tissue consequently which separate them from each other.

This tissue, on the contrary, is very abundant along the anterior part of the spine, or in the neck where it accompanies the carotids, in the trunk and abdomen where it attends the aorta, the large trunks which arise from it, the venæ-cavæ, et azygos, &c. There is no part in the animal œconomy more frequently liable to sinuses than this is. We frequently see abscesses, that have formed at the anterior part of the thorax and abdomen, discharging themselves at the groin by means of those sinuses whose tract is exposed by dissection. It is chiefly by these cellular communications, and those that exist under the integuments, that the upper parts of the body correspond with the lower, and vice versâ.

Cervical Cellular Tissue.

The neck, which is furnished abundantly with muscles, contains a considerable proportion of cellular tissue, exclusive of that which belongs to the spinal column. This tissue is most remarkable about the sides of the neck, where the lymphatic glands are seated. We find also a large quantity in the space between the sterno cleido mastoideus and the trapezius, where we observe the origin of the brachial nerves, and the course of the vessels proceeding from the chest. It communicates with that of the chest, through the large aperture at the superior part of that cavity; hence, when any of the cells of the lungs are ruptured, the air that escapes forces itself from the chest into the neck. Hence too, the facility with which the same effect is produced in blowing up the cellular substance, underneath the pleura, &c. &c.

The cellular tissue of the neck communicates also with that of the superior extremities both above and below the clavicle; this is the reason why the neck, and subsequently the chest, fill with air, water, or any other fluid that is injected into the sub-cutaneous tissue of the extremities, and particularly the intermuscular.

Cellular Tissue of the Chest.

In the cavity of the thorax, it is particularly at the median line that this tissue is found; the space that divides the two mediastina is abundantly supplied therewith; the neighbouring parts about the pericardium are overloaded with it, and particularly the large vessels which it attends for a short distance. The remaining part of the chest which is occupied by the lungs has not so large a proportion. The pectoral tissue communicates with the abdominal: 1st. Through the different openings of the diaphragm, that of the aorta and œsophagus especially, the cellular covering of the vena cava is too closely adherent to this vessel to allow freely of such communications. 2ndly. Through the interstices of the fibres of the diaphragm, and particularly in the triangular space, which those that are attached to the ensiform cartilage leave between them: this accounts for the passage of pus from the chest into the abdomen. Desault used to relate a case, in which a collection of matter that had formed originally at the neck, made its way through the anterior mediastinum, and pointed at the upper part of the abdomen. This then explains again the readiness with which the pleuræ partake of the diseases of the peritoneum, particularly the right pleura, when the latter is diseased on the convex surface of the liver, which is fixed and immoveable, whilst that which covers the stomach and spleen, being subjected by their motion to a change of situation, exerts much less influence over the left pleura.

The cellular communications of the thorax, externally and internally, take place through the intervals of the intercostal muscles, but they are not strongly marked, in consequence of the smallness of these intervals. Diseases of the chest accordingly rarely extend their influence to the outside of this cavity; this however sometimes happens, as in cases of dropsy, and chronic inflammation of the pleuræ, where the integuments of the chest present the leucophlegmatic appearance on the diseased side. The cellular tissue on the outside of the chest is abundant at the upper part, it surrounds the breasts, giving it that soft and voluptuous swell which so delights us in woman, and that bold and prominent outline which is so striking in the well proportioned figure of the male. Under the pectoral muscles a great quantity is also found, which gradually decreases as it descends.

Abdominal Cellular Tissue.

The abdomen is in proportion supplied with somewhat more of this tissue than the thorax. Within its cavity, this tissue is accumulated in those parts where the large trunks of the arteries and veins enter into the different viscera, in the cleft of the liver, the mesentery, &c. It is not very considerable between the peritoneum, and the anterior and lateral parieties of the abdomen; but at the posterior part of this membrane, and particularly about the kidneys, it is abundantly produced. This tissue internally is connected, first, with that of the pelvis round about the peritoneum, afterwards with that of the inferior extremities, by means of the various apertures, the abdominal ring and crural arch particularly. The first of these openings establishes a cellular communication between the abdomen and the genitals, particularly in man. These communications are easily brought into view by injecting a fluid into the abdominal cellular tissue of the subject, it penetrates with the greatest ease into the lower extremities while it requires some force to propel it into the superior. It is almost generally known, that there is scarcely any case of ascites which is not attended with infiltration in the lower extremities, whilst the upper remain unaffected. The cellular tissue then of the abdomen, as Portal and Bordeu have correctly remarked, is especially connected with that of the lower extremities, in the same way as the cellular tissue of the thorax communicates with that of the upper extremities. It is to be observed however, that the former are much sooner affected by the diseases of the abdomen, than the latter by those of the thorax.

Cellular Tissue of the Pelvis.

There are few parts in the animal œconomy, in which the organ now commanding our attention has been distributed with more profusion than the pelvis. It exists in great abundance about the bladder, rectum, and womb. This appears to depend on the following cause: as on one hand these three organs are subject to great increase of capacity, and on the other the bony parieties of the pelvis can in no wise accommodate themselves to their dilatation, as is the case with the parieties of the abdomen, it was necessary that something should be substituted so that the cavity of the pelvis should be filled up, whatever might be the state of the above organs.

This liberal provision of cellular tissue is accordingly devoted to this particular use. If the motions of the brain, like those of the latter, were alternately to increase and diminish the bulk of the organ, nature, undoubtedly would, on account of the hard and unyielding cavity in which it is lodged, have provided it abundantly with cellular tissue.

To conclude, we well know the influence of this increased proportion of the cellular tissue in the pelvis, in abscesses adjacent to the anus, extravasations of urine, arising from some breach in the bladder, or urethra, &c. We are aware of the facility with which pus and urine extend in such parts, and the danger that attends their ravages.

This tissue communicates with that of the inferior extremities through the ischiatic notch, under the arch of the pubis, &c. Several authors have related cases where fistulous sinuses and extravasations of urine have extended to the lower parts by such communications. We can fill the pelvis with air by inflating the inferior extremities, and particularly the intermuscular tissue. The cavity of the pelvis is covered externally with much cellular tissue, but more laterally than posteriorly, and particularly at its anterior part, where the generative organs of either sex are furnished with a plentiful production of this substance, especially the labia and dartos.

SECTION III.

Cellular System of the Extremities.

In both the superior and inferior extremities, the quantity of cellular tissue gradually decreases from the upper to the lower parts. It is extremely abundant in the neighbourhood of the two great articulations. The cavity of the axilla, to which the head of the os humeri corresponds, and which is sufficiently capacious, is almost entirely filled with it. The flexure of the groin is plentifully supplied, although not in so great a proportion as the axilla. The arm and thigh have considerable spaces between their muscles which are occupied by this substance. We find much less, comparatively speaking, at the elbow than in the ham, in whose hollow a great quantity is lodged: an arrangement which is precisely the reverse of that of the axilla compared with the groin. In the fore arm and leg where the muscles are more compact in their arrangement the cellular layers are more condensed, and the whole cellular system much less abundant.

Towards the terminations of the extremities, which are almost entirely tendinous and fibrous in the hand and foot, the cellular tissue still diminishes, and in proportion to motion, is considerably reduced. The foot, nevertheless, particularly at the sole, is provided with a greater quantity than the palm of the hand, where hardly any is to be found.

This gradual decrease of the cellular tissue in the extremities, is appropriated to the uses of their various parts. In fact, the extensive motions that are performed in the upper part of the body required considerable laxity in the muscles, which they derive from the cellular tissue that surrounds them. Lower down the multifarious, and at the same time limited motions, of the hand and foot, particularly the hand, which is formed to mould itself to external bodies, require the nicest and closest apposition in the organs of these two parts, which they owe to the scarcity of their cellular tissue.

ARTICLE III.

Of the Structure of the Cellular Membrane, and Fluids it contains.

SECTION I.

Cells.

The general conformation of the cellular membrane is not in every part the same. The interstices or cells that are formed by its several laminæ vary in size: they are particularly capacious in the eyelids and scrotum, and also in such parts as have little or no fat. The dimensions however of these cells are exceedingly variable, and as they admit of contraction and dilatation, nothing positive can be ascertained in this respect. When filled with fat or serum, they are many degrees larger than what they are when empty. It is these variations in the capacity of the cells of the system we are now examining, which determine the various differences in the general bulk of the body, from the state of corpulence to that of emaciation, in both which states the size of every muscular fibre and nervous filament remains almost entirely the same, and in which this system only undergoes a change. In cases of dropsy we observe the same variations when we compare the usual state of the body.

The figure of the cells is also so various that they cannot be described in a general manner; some are circular, some quadrilateral, &c., and all curiously mingled together. The best way of investigating them, is to submit an infiltrated limb to congelation: a thousand small icicles will form and assume the shape of the containing cells. Inflation is again a useful method: I have frequently by this experiment ascertained the shape of cells in the markets where meat is inflated. Injections of melted gluten into the cells may also be employed; but the results are not so certain, because in passing from cell to cell it frequently breaks the tissue, and besides, after it coagulates it is a very difficult thing to separate each individual portion contained in the cells.

All the different cells communicate with one another and in such manner, that the cellular tissue is actually permeable throughout the whole extent of the body, from head to foot. A thousand examples may prove this fact: 1st, emphysema spontaneously produced; 2dly, That, artificially made in a living animal, by inflating the cellular substance, an operation which is not destructive of life, nor even injurious to the health of the subject although often the whole of the body may be tumefied. It has been ascertained that mendicants have employed these means to excite commiseration, without the slightest prejudice to themselves. 3dly, If two or three small punctures be made in a dropsical limb, the contained fluid will sometimes be completely discharged through these apertures; 4thly, this is also frequently the case where the integuments have given way; 5thly, pressure applied to them, causes the fluid either to ascend or descend, according to the direction in which it is applied; 6thly, an opening in the bladder, or urethra, will cause extravasation of urine, which sometimes extends to the sides of the chest; 7thly. injections of any kind of fluid into the cellular tissue of the dead body will produce artificial dropsy.

The permeable state of this tissue has been much exaggerated, or rather it has been represented under a very different aspect from that in which nature displays it. Thus it is, that several physicians supposing it might admit indiscriminately the passage of all the fluids of the animal œconomy, have considered these fluids as currents flowing more or less regularly in different directions. Thus perspiration has been considered as an exudation of the albuminous fluid of the cellular tissue through the skin, which, in the opinion of some modern authors, is thrown off with the caloric, that is constantly disengaging itself from the surface. Thus, also, the permeability of this tissue has been assigned to account for the rapidity with which fluids are conveyed to the bladder, and perspiration is excited by warm diluents, &c.

Such theories as these, that inspection never fails to disprove, are totally repugnant to the known laws of the living œconomy, laws that shew us these fluids constantly circulating in the vessels, by the agency of the vital powers, of the organic sensibility and contractility of these vessels, and never exuding from those which afford them a proper channel to enter into one that is not natural to them. I have never found a drop of fluid in the cellular membrane of animals immediately after drinking. I have submitted several dogs to the experiment, after having deprived them for a length of time of water, and then compelled them to drink a great quantity. The cellular tissue about the stomach and intestines, and particularly that part behind the mesentery which communicates with the pelvis at the seat of the bladder, having been attentively examined, has appeared to me to contain no fluid; it was precisely analogous to that of other parts of the body. Besides, as we shall ascertain hereafter, these phenomena admit of a more natural explanation.

It is evident then, that the cellular tissue is only permeable to fat and lymph, and rarely in any unusual degree in the ordinary state. These two fluids remain in their cells until they are removed, or rather resumed by absorption, and are never seen to proceed from the one to the other, but are, if I may so express myself, stagnant. It is only in serous infiltrations, in collections of pus, in a word, it is only in a morbid state, that the permeability of the cellular tissue evinces itself. We can only then regard the cellular tissue as a reservoir for the formation of fat and serum. After death, the cellular tissue affords a quick passage to fluids, which not only penetrate into the different openings of communication between its cells, but also through the pores which constitute a necessary part of it as well as the solids; hence the transudation we observe from the integuments of the back, in bodies that have remained a long time on that part; hence also the oozing out of bile, which escapes through the tissue that separates the gall bladder from the duodenum, and deeply colours this intestine, &c. &c., but these phenomena have no connexion with such as are exhibited in the living subject.

SECTION II.

Of the Serum of Cellular Tissue.

The first of the two fluids in this system, seems to be perfectly the same as that which is furnished elsewhere by the exhalants, and taken up again by the absorbents. The former deposit it in the organs, and the latter resume it. Accordingly, when we expose a certain part of the cellular tissue in an animal recently slain, and preserving heat, to atmospheric air, condensed by cold, we observe a vapour to arise, which is occasioned by the dissolution of serum on its contact with air, a vapour perfectly analogous to the cloud that is produced from our lungs and skins in winter, or that which arises from an aqueous fluid of a high temperature, and exhaled from a large surface, on its exposure to cold air. When the temperature of atmospheric air is increased, the dissolution takes place in the same way, but there is no apparent cloud, as the vapour is not condensed.

Cellular serum varies in quantity according to the situation where it is produced. It seems to be rather more abundant in such parts as are deprived of fat, namely the scrotum, eyelids, prepuce, &c. It is likewise to be observed, that these parts are much more liable to infiltrations of fluid: under this head the scrotum ranks first, next the eyelids, and lastly the prepuce, &c. We must here remark, that the cellular tissue external to mucous surfaces, to arteries, veins, and excretories, a tissue which resembles the latter in the absence of fat, differs from it in respect of serum, being, as I have already mentioned, subject to no serous infiltrations.

I must remark, that we cannot judge of the quantity of cellular serum, by observations made on the dead body, the laxity of whose various parts allows the several fluids to transude through their vessels, and penetrate the surrounding cellular tissue. To determine the quantity of moisture, I first distend the integuments of an animal with air, so as to produce emphysema, and afterwards make a pretty free incision along the skin, which is followed by a very slight effusion of blood, owing to the collapse of the vessels, produced by the general tumefaction.

Having laid bare the cellular tissue by these means, I have frequently satisfied myself, that it does not contain so large a quantity of serum as is generally thought. I have found, that the cellular serum is much increased or diminished during digestion, or after sleep, when the skin is in a copious state of perspiration,—circumstances under which I have repeated these experiments. This fact perfectly coincides with that I have stated in my treatise on membranes, respecting the fluid which lubricates the serous surfaces, and is almost always found in the same proportion.

It is well known that in cases of anasarca the quantity of cellular serum is very much increased, and is entirely suspended in inflammation, &c.

This fluid appears to be absolutely albuminous in its nature, as is proved by chemical experiments made in dropsical cases; but may it not have been changed in its properties by disease? To ascertain this fact, I inflated a dead animal so as to dilate the cells, for the purpose of affording an easy passage to an injection of alcohol, which I afterwards introduced by means of a syringe. Having stript it of its integuments, a few moments after I observed here and there divers whitish flakes in the subjacent tissue. I have made the same observation on immersing into diluted nitric acid, a small portion of the cellular substance of the scrotum that I have removed from the dead body immediately after death, or what is still better, from the living animal. It appears then, that in both states of health and disease, albumen is one of the essential principles of the fluid of cellular tissue. I have extracted a considerable quantity of this tissue of the scrotum from different subjects, separating it from fat, and I have boiled it with an equal proportion of tendinous matter; at the instant of boiling, a white froth has risen to the surface of the water, but in the vessel which contained some preparations of minutely dissected tendons, very little appeared.

Is the cellular fluid of the same nature as the lymph, which circulates in the absorbents? There is no doubt that this species of vessels reabsorbs the fluid from the cells, but other substances may possibly be mingled with it, and especially those produced by nutrition, which changes its nature. We can ascertain nothing by chemical analysis on this head.

SECTION III.

Of Cellular Fat.

Fat is the other fluid contained in the cellular tissue.

Natural proportions of Fat.

Fat is very abundant under the skin, about the serous surfaces and organs, having extensive motion, &c., but is wanting, as we have heretofore stated, in the penis, prepuce and scrotum, &c. It is also deficient in the mucous surfaces, about the arteries and veins, &c. Its quantity varies in the structure of various organs: we find none between the coats of the arteries and veins, none in the lymphatic glands; none in the brain and medulla spinalis, &c. It is however always found between the filaments of nerves, although it is very indistinctly seen, but we find that their fibres in drying allow an oily exudation to escape, which occurs invariably, and is evidently produced by it. It is generally found in some quantity in muscular fibres, particularly in those of animal life; we scarcely see any in those of organic life. In bones, which are destitute of it, it is replaced by the medullary juice; cartilages, tendons, and fibro-cartilages, are almost wholly unprovided with it. It is sometimes observable in certain parts of the glandular system, as in the parotid gland, the pelvis and the kidneys, but in others we find no vestige of it, as in the liver, and prostrate gland. The serous and cutaneous systems have no adipose substance in them although surrounded by it. It is not found in the epidermis nor hair.

From the foregoing hasty sketch, it is evident that the internal structure of organs, contains commonly but an indifferent proportion of fat. The appendages of viscera themselves have but little of it; thus, between the coats of the stomach, intestines, and bladder, &c. between the periosteum and bone, between the latter and cartilage, between muscle and tendon, &c., this substance is hardly ever to be found.

It is therefore principally in the spaces of the various organs that fat accumulates. Accordingly, examining it under this aspect in the different parts, we find; 1st, that the head, cranium, and face, are differently circumstanced; it is very abundant in the latter, and wanting in the former, particularly in its internal structure; 2dly, that the neck is provided with a sufficient share; 3dly, in the chest, there is very little about the lungs, but a great quantity in the neighbourhood of the heart; externally, and at its superior part it presents a mass about the mammæ; 4thly, in the abdomen, this fluid is especially abundant at its posterior part in the neighbourhood of the kidneys, mesentery, and omentum; 5thly, in the pelvis, it is accumulated largely about the bladder and the rectum; 6thly, in the extremities it is found like the cellular tissue, in greater abundance in the superior ones, and near the large joints.

We observe, that in the infant the quantity of fat is found in a much larger proportion under the skin than in any other part, and particularly in the abdomen, whose cellular viscera, and especially the omentum, contain none at that age. I have ascertained this fact in several subjects. There is very little of this substance about the kidneys, and that little is hardly perceptible; the other parts of the abdominal cavity are totally unsupplied. The chest does not seem to contain much more, and always much less in proportion than what it subsequently has. I have also ascertained, that the intermuscular tissue is almost every where deprived of it. We might say that the whole of this fluid is concentrated under the skin, at least as long as the fœtus thrives. Does this redundance of sub-cutaneous fluid answer any important office? Is it any way connected with the extraordinary bulk of the liver at that period? I cannot tell; it is a phenomenon well worthy the attention of physiologists, particularly if we compare it with the total absence of fat in almost every part where it afterwards accumulates.

In the adult, there is a far larger proportion of fat in the abdomen than under the skin. Corpulency of that part is as rare towards forty as it is common till the fourth or fifth year, at which time of life all the muscular parts being concealed by the superabundance of fat, the body is generally rounded. Has the considerable proportion of abdominal fat in the adult any relation with the frequency of diseases of which this cavity is the seat at this time of life? The proportions of fat however in various stages of life are not so general but that they admit of many exceptions.

In old age, this substance is almost all melted away, and disappears, the body wrinkles, contracts, and withers into a spare and extenuated state.

Unnatural proportions of Fat.

It frequently accumulates in very large quantities in the cellular tissue. I shall not cite instances of those enormous collections which authors have related in a variety of cases; this would be entering into needless details. I shall simply observe that this state of extraordinary corpulency, far from indicating health, almost invariably denotes a debilitated state of the absorbents, destined to re-absorb this fluid, and that, in this respect, it bears more analogy to serous infiltrations than is generally supposed. Several facts support the assertion. 1st. All kinds of extraordinary corpulence are attended with weakness in the muscular powers, and a state of languor and lassitude in the individual; 2dly. In a strong and athletic subject, we do not observe this unhealthy fulness which would conceal the fine movements of muscle, so strongly developed throughout his frame. We must carefully distinguish that bulk of body, which is produced by an accumulation of cellular fat, and that which is occasioned by the developement and perfect nutrition of the organs: 3dly. Causes often, that evidently exhaust the vital strength, will give rise to a considerable increase of bulk: as inaction, rest, violent hemorrhages, and convalescence after certain acute diseases, in which, although the living powers are not quite restored, adipose substance already abounds; 4thly, whenever muscles are loaded with fat, they are manifestly in a state of actual debility; 5thly, I have frequently convinced myself on examining limbs in a state of atrophy, that the little bulk they preserve is partly owing to the fat which they contain, and which is comparatively almost equal to that of the healthy organs, while all the other parts are shrunk and wasted, particularly the muscles. Castration, which deprives the vital powers of part of their activity, and nutrition of part of its energy, is very frequently attended with excessive corpulence; 7thly, on the other hand, as generation requires a certain degree of developement in the vital powers, corpulent subjects being deprived of such a degree of energy, are generally unfitted for this function; in the female this is a very remarkable fact, and not less so in the man. The same observation applies to animals. In proportion as fowls are fattened for our meals they become less fit for laying eggs; the greater number of domestic animals are subject to the same law. We might suppose that there is a strong and uniform relation existing between the secretion of semen and deposition of fat, and that these two fluids are in an inverse ratio to one another.

We must conclude then, from the preceding facts, that if a moderate exhalation of fat denotes strength, its superabundance denotes weakness, and that there is in this respect, as I have already stated, a certain relation between serous and adipose infiltrations. We must remark nevertheless, that dropsies, almost invariably, proceed from organic derangement of some viscus; especially the heart, lungs, liver, womb, and spleen, from whence it results that they are hardly ever subdued but usually terminate in death: which is the unavoidable consequence, not of dropsies, but the organic disease. On the contrary, it rarely happens that superabundance of fat, which is not incompatible with longevity, is attended with such like change of structure. If there were no other change in dropsy but cellular weakness, I am convinced that it would not interfere with the regularity of the functions.

Considerable collections of fat are frequently the immediate result of some outward cause of atmospherical influence: for instance, thus a fog will, in the space of twenty-four hours, fatten thrushes, ortolans, red breasts, &c. to such a degree, that they can scarcely fly from the sportsman's gun. This phenomenon, which is not unfrequent in Autumn, is rarely apparent in man.

The decrease of fat is as frequent as its increase, and we may say, there are more instances of excessive leanness than extraordinary corpulence. The causes of such decrease are as follows: 1st. Long abstinence from food, as is exemplified in the protracted fasting, and sleep of torpid animals; so that in this instance fat may be considered as a supplementary provision, which nature has reserved for herself when her ordinary nourishment fails; 2ndly. Organic affections of long standing, as consumptions, cancers of the pylorus and womb, diseases of the liver, heart, &c.; thus, professional men who are in the habit of dissections, are able to judge by the external aspect, and without being acquainted with the antecedent disease, if the structure of a vital organ be injured or not. Generally speaking, in organic affections there is not only emaciation, but also an alteration in the nourishment of the organs; they are reduced in size. On the contrary, after an acute fever, which has lasted but a few days, leanness only is observable. Nutrition, a function which is altered slowly as it is exercised slowly, is scarcely disturbed in that time. In this respect there exists a very material difference between two subjects equally lean; we need only dissect a limb in each, generally speaking, without inspecting the viscera, to ascertain if death has been occasioned by the slow and gradual effect of organic disease, or be the quick result of a bilious or putrid fever, &c. To causes already enumerated we may add : 3dly. Suppurations of some extent, and particularly those which proceed from chronic affection ; 4thly. Dropsy, although we must not think that fat and serum mutually exclude each other, since large quantities of sub-cutaneous fat are observed in dropsical subjects ; 5thly. All depressing affections of the mind, which operate especially on internal life, and affect its organs, more particularly, than those belonging to external life ; 6thly. Long and unremitting applications of the mind, with which the brain is especially concerned, and whose immediate influence is consequently exerted on animal life ; I must however, observe, that the disordered state of the functions of this life have much less influence on corpulence, than that of the functions of organic life ; 7thly, All secretions preternaturally increased, such as bile, urine, saliva, &c. ; as also the frequent emission of semen, &c. increased discharges from the lungs and intestines, &c. ; 8thly. The excessive and long continued heats of summer, when compared with the chills of winter, which are more favourable to the production of fat ; 9thly. Prodigious bodily exertions, hard labour, extreme fatigue ; 10thly. Chronic diseases, where patients are compelled to subsist on a spare diet, or sometimes to exist absolutely without food ; 11th. Painful and long continued lucubration, (such sleep producing quite a contrary effect, that of promoting corpulency); 12th. An immoderate use of spirituous drink, &c. &c.; 13th. A frequent use of strong spicy substances, or such as contain properties the reverse of farinaceous ones, &c. &c.

I shall omit many other causes producing extenuation, the reader may easily supply them from such as I have mentioned. I shall merely remark, that they almost all proceed from two principal causes, namely: 1st. A general diminution of strength, operating on the cellular system in common with other parts, and producing this phenomenon; 2ndly. Partial diminution of the strength of this tissue, proceeding from the affection of some particular organ, whose action seems to increase at the expence of that of the cellular texture.

The different States of Fat.

Fat is almost always solid and coagulated in the dead body; but in the living subject it approaches nearer to the fluid state, at least in certain parts, as in the neighbourhood of the heart, large vessels, &c. It has uniformly more consistence under the skin. In the numberless experiments I have had occasion to perform on living animals possessed of red and warm blood, I have never found it, generally speaking, in the positive fluid state which fusion presents, notwithstanding the assertions of several authors, which have been founded on the opinion that vital heat must reduce it to such a state. It cannot be doubted that a certain degree of caloric equal to that of our own temperature, acting on fat that has been removed from the human body, will render it more fluid than it is in the living subject. Moreover, we are well aware that the degree of temperature is nearly the same throughout the whole œconomy, and yet is remarkably variable in the degrees of its consistence. There is a striking difference between the adipose substance of the omentum, which verges most on the fluid state of the whole system, and that accumulated about the loins, and under the skin, which is much firmer. Cold and red blooded animals, are possessed of fat in a fluid state, &c. In general it appears, that the nature and state of this substance differ considerably in different parts of the system, and that its various accumulations found in the cavities of the abdomen, thorax, and brain, have distinct properties, although we have no precise idea of their difference.

In young animals it has a whitish hue after death, and is more solid and consistent. It is this very consistence which affords singular firmness and hardness to the integuments of the human fœtus, whilst in the adult, the skin being loose and flaccid, yields to the slightest impulse, on account of the state of the sub-cutaneous fat. In the fœtus fat is accumulated in small globules, more or less of a spherical form, which give it a granulated aspect. We find it frequently in considerable quantity in different parts. There is almost always, for instance, in this stage of life, a distinct mass or ball of fat between the buccinater, masseter, and integument, which forms a distinct body from the surrounding substance, and which may be removed entirely by itself. It contributes powerfully to the plumpness for which the cheeks are remarkable at this period of early life.

Fat gradually assumes a yellowish hue as the subject increases in age, and a peculiar and characteristic odour withal. We perceive the difference, on comparing the fat of veal with that of beef, prepared for our repast. In the dissecting room, this distinction is not less striking between a subject ten years old and one of sixty.

We frequently find a yellowish transparent fluid substance, of a jelly-like appearance, and approaching to albumen, substituted for fat in the neighbourhood of the heart, in subjects that have died of dropsy, phthisis, or long protracted visceral disease. It occurs also in other parts of similar subjects, but less frequently, appearing to partake more of the properties of gluten than oil.

Exhalation of Fat.

Divers hypotheses have been advanced as to the manner in which fat is separated from the blood. Malpighi averred the existence of certain glands and excretory ducts that no other anatomist has perceived since his time, and no one believes in the present day. Haller supposed that this substance was entirely formed in the arterial system, circulated with the blood, and floated on the surface of the blood, owing to its being specifically lighter. Thus circulating, it escapes, according to his opinion, through the pores of the arteries, and oozes out into the cellular tissue. Such an opinion implies two things: 1st. The existence of fat entirely formed in arterial blood, an existence that is proved by no positive fact, and of which I have never been able to convince myself by the minute inspection of red blood taken out of the vessels, and which nevertheless, if this were the case, would infallibly exhibit numerous small particles floating on the surface of the liquid at the moment it is drawn. In my experiments on the colouring principle of blood, I have repeatedly ascertained this fact. I have also observed it in the blood of maniacs upon whom arteriotomy was performed in the Hôtel Dieu; 2dly. Haller's opinion is founded upon transudation wholly mechanical, that is quickly produced in the dead body, but never takes place in the living. In short, if we expose one of the arteries of a living animal, and separate it distinctly from the surrounding tissue, we shall not find on examining it for whatever space of time, that there is any oozing out of fat through its parieties, although the circulation of blood be carried on as usual. There are an infinite number of arteries which penetrate the cellular tissue, without ever depositing this substance, as we see in the scrotum, eyelids, &c. Now in these parts the arteries are on the one hand organised as elsewhere, and on the other, fat must be formed in equal proportion in the blood that they convey, consequently, according to Haller, we must suppose that fat also transudes through them. Besides, we shall find in the chapter on exhalation, that this transudation through the arterial pores, whatever be the fluid supposed to transude, is utterly at variance with the laws of the animal economy. I must refer to this chapter for the proofs which I have advanced, to shew the falsity of Haller's doctrine. We shall also find in the same chapter, that fat is separated by a process of exhalation, purely analogous to that of all other exhaled fluid, that is to say, by vessels of a peculiar order, intermediate between the arterial extremities and the cellular tissue. Some authors have affected to see distinct vessels circulating fat, and have described them under the denomination of adipose vessels; but it appears that like all other exhaling vessels, they baffle the minutest inspection, and can only be proved by a series of deductions, which, notwithstanding, clearly demonstrate their existence. We may safely apply the remarks that we shall offer in general on the exhalant vessels to the system of exhaling vessels that secrete this fluid.

I shall pass over the chemical properties of fat, the acid it contains, the peculiar changes of which it is susceptible under different circumstances; that, for instance, which it undergoes, when animal substances containing it, as the skin, muscles, &c. have been long submitted to maceration in water. This would involve me in a series of details foreign to this work, besides, I could add nothing to what has been stated on this head by modern chemists.

I shall conclude this article with an important observation. In those parts which nature has deprived of this secretion, its existence would have unavoidably interfered with their particular functions. The penis would no longer have been proportioned to the vagina. The eyelids, overloaded with fat, must have failed in the performance of their offices. The cavities of the different organs lined by mucous membrane must have been straitened and retrenched by its being accumulated in the sub-mucous tissue. Had it been diffused throughout that which surrounds the arteries, veins, and excretories, it would equally have obstructed the calibre of these vessels, and we must remark that its invariable defect in the subarterial tissue, is another proof contradictory of Haller's opinion. Had it been accumulated in the cavity of the brain, it would have compressed this organ, on account of the resistance of the bony parieties of the cranium, &c., which do not give way like those of the abdomen when its viscera are full of fat. In the chest the diaphragm descends, and affords larger space to the lungs without any prejudice to them, when there is much fat secreted in the mediastinum. This remark, which is also applicable to the serum, explains an important phenomenon in diseases; namely, that the slightest quantity of fluid effused in the tunica arachnoides, is sufficient to disturb the functions of the brain, whilst a considerable accumulation in the abdomen or chest, is attended with no immediate danger.

ARTICLE IV.

Organization of the Cellular System.

The cellular system, is, like almost all the other systems of the living economy, composed of a tissue peculiar to itself, and of parts common to others.

SECTION I.

Tissue peculiar to the Organization of the Cellular System.

Much has been written on the nature of this tissue. Bordeu has advanced some very vague ideas on this subject, unsupported by any experiments. Fontana has made many fruitless researches in respect to its intimate structure and the tortuous cylinders, of which, according to this author, it is entirely compounded. Let us dismiss all such hypotheses as are not confirmed by minute inspection; let us follow nature in those phenomena of structure that she reveals, but not in those that she conceals from our sight. Accordingly, in thus considering the cellular tissue, we find it to be perfectly distinct from that species of gluten to which some authors have been pleased to compare it; it is an assemblage of innumerable whitish threads, that are ramified over the thin laminæ or plates that unite with these threads to form the cells. To acquire a perfect knowledge of its structure, we must take a portion of cellular tissue from the scrotum without fat, which might else conceal its texture—draw it out into the thinness of membrane, and examine it in a favourable light. We shall then clearly distinguish a thin transparent web arranged into plates, which form its principal part, and of such exquisite delicacy that they may be compared to air bubbles. We can discern no fibres in the texture of these plates which are perfectly uniform. They are evidently crossed by an infinity of filaments, which follow no precise direction, are variously interwoven together, and are in close contact when the cellular tissue is gathered and condensed into a packet, but once distended, exhibit these plates of which I have spoken in the spaces between them. Consequently, in extending the cellular packet, it forms a membrane of considerable breadth—the filaments are drawn asunder so as to leave certain interstices between them, wherein the intermediate plates are distinctly seen.

What is the nature of these filaments? I am disposed to think that some are absorbents, others exhalants, and, that a certain number are formed for the formation of cells at that part where the plates are united together. In short, we observe lines strongly marked on the cellular tissue when it is stretched out, corresponding to the union of the plates where the thickness of the tissue is increased. I am induced to think so from the following circumstance:—If, instead of pursuing the preceding mode of investigation, we examine the cellular tissue in a state of artificial emphysema, as it is exhibited in the market, we shall only perceive the non-filamentous plates I have been describing on the envelope of each cell without any of those filaments which pervade other parts of the membrane.

These plates have not, invariably, the same thickness; they are sufficiently dense when the cellular tissue is close and contracted, but become so slight and delicate when it is distended with air or any other means, that it is impossible to conceive any thing like organization in this thin etherial substance. It does, however, really exist, in spite of opinions that have been entertained to the contrary. In fact, what is a tissue, I would ask, which is nourished like other parts, inflames or suppurates, is the seat of distinct vital functions, and has an inherent property of life, if it be not an organic tissue? All these indefinite notions of concrete juices, inorganic gluten, coagulated juice, that have been founded on the cellular tissue, rest on no individual observation or experiment, and must be discarded and banished from a science where imagination goes for nought, and facts are every thing.

The cellular tissue displays marked varieties of organization: wherever fat or serum is deposited, we find the cells in form of minute pouches or bags, which communicate together, and form so many receptacles, the parieties of which are composed of the transparent and non-filamentous plates of which we have spoken;—it is in these bags that fat and serum are secreted.

On the other hand, we find none of these pouches, or, more properly, cells, and none of the plates that form them, in the submucous tissue, or that which constitutes the outer coat of arteries, veins, and excretories. If we remove this membrane with care, we shall perceive, on raising it from the surface beneath and drawing it out, to bring their texture into view, a multitude of filaments crossing each other in different directions, and forming a network, as it were, of meshes, but not pouches or distinct cavities. This network is quickly distended with air when it is forced into the neighbouring tissue, but as soon as a puncture is made it escapes and the tissue collapses,—whereas that accumulated in the common tissue, subcutaneous or intermuscular, remains in the cells, although they be in part exposed with the knife, doubtless because the openings of communication between them are very small. We observe frequent instances of this in the markets, where the cells are seen considerably expanded round the meat which is divested of the skin.

It appears that these filaments, interwoven in every direction with one another, and forming a cellular network round the vessels and under the mucous surfaces, are precisely of the same nature as those scattered here and there about the membranous plates of which the cells are formed ; the only difference is, that they lie in closer contact with each other, and are distinct.

From what I have stated above, it would appear that the common cellular tissue is composed of two things, 1st. Of an infinitude of numberless thin transparent plates, occurring wherever the tissue is loose, susceptible of sudden distension from various causes, and readily retaining the fluids which are enclosed in its cells; 2ndly. Filaments intermingled with those plates wherever they occur, but existing alone in other parts. These cellular plates and filaments have a peculiar tendency to absorb atmospheric moisture. This tendency is particularly obvious in dissecting-rooms, where a subject, that is perfectly dry and easily dissected in the morning, is often completely infiltrated towards evening, if the weather has been humid. This infiltration then must have taken place in the cellular system, which in such cases may be considered as a true hygrometer.

Composition of the Cellular Tissue.

This tissue has been included by certain chemists in the general class of white organs, or those that afford a large quantity of gelatine. In fact, it furnishes a certain proportion, and a remarkable precipitate may be obtained by means of a dissolution of tannin from water in which this tissue has been boiled, without any other organ, excepting the vessels with which it is supplied, as, for instance, that of the scrotum. I have made this experiment myself. Different substances, however, operate differently on this tissue to their usual mode of action on the skin, cartilage, fibre, &c.

When exposed to air, the cellular tissue dries quickly, but does not assume the yellowish hue peculiar to fibre: it remains white. When dried in laminæ of a moderate size, the cells adhere to each other, and the laminæ being somewhat distended for the purposes of dessication, have the appearance of a real serous membrane when the process is completed. In this state the cellular membrane is quite pliable, and bends every way with the utmost facility. It has not the stiffness of dried fibre, and when immersed again in water, does not perfectly resume its first appearance, and its cells are with difficulty unravelled.

Submitted to putrefaction with other animal substances, it does not yield so readily as some of the latter, as, for instance, the glandular and muscular parts; when distended with the juices of putrefaction, it is not so quickly decomposed as the other parts by some space of time. This fact is particularly striking in the sub-mucous tissue, or that which surrounds the vessels; the filaments of which it is composed offer much more resistance than any other part of the cellular tissue to the putrefactive process.

It is the same with maceration as the preceding phenomena. On comparing tendon with cellular tissue, it would seem that water softens the former much sooner than the latter, and yet the one is quite pulpy and reduced almost to a fluid state, while the other is scarcely affected. I have observed no alteration whatever in the cellular sheath of arteries after three months maceration in water, at the degree of temperature common to cellars. Sub-cutaneous, sub-serous, and intermuscular tissues are much sooner affected, but less in proportion than those of other organs. I have a preparation of nerves, which I have preserved six months ago in a glass, yet on them, for reasons that I shall explain, maceration has produced no sensible effect; the tissue that separates its fasciculi, is in every respect as firm and as distinct as before. Cellular tissue yields more easily to the action of water when it is macerated with other organs, which are more soluble and therefore reduce it also to putrescency, than when it is macerated alone.

What renders this resistance more remarkable, is the extreme delicacy and porousness of its tissue, which must subject it more thoroughly to the action of the fluid. I am convinced that if the tissue of tendons, cartilages, fascia, skin, &c. were prepared in laminæ equally fine, and separated in like manner, that three or four days maceration would suffice to reduce them to a state of putrescency. The same observation applies with equal force to ebullition—a few moments would detroy and reduce most of the white tissues to jelly, if they were disposed in layers as fine as the cellular system—this however resists much longer; several plates may still be seen between the fibres of the boiled muscle. Fat which after concoction is still found in masses in the midst of the fleshy fibres, would naturally escape if the cells which contain it were not perfectly entire; we can, besides, easily ascertain the existence of laminæ in these fleshy masses. The action of boiling-water is long of effect on the cellular sheath of arteries, excretories, &c.

Moreover, cellular tissue submitted to concoction, displays the same phenomena as every other organ treated in the same manner: 1st. It remains soft, or nearly in its wonted state, until an albuminous froth covers the surface of the water in which it is immersed; 2ndly: When this follicle forms, it shrinks, contracts, and is reduced to a smaller size. This contraction increases till the process of ebullition takes place, which almost immediately follows. In this state the tissue is denser and more elastic, after being extended it contracts immediately to its former state, which it did not before; 3dly. It softens by degrees while ebullition is going on, and loses its contractile power, its extensibility is also nearly destroyed; in the natural state it is capable of being elongated without rupture, which now takes place from the slightest effort; 4thly. It is gradually dissolved by the continued action of boiling water. I have noticed that at no period of ebullition does it assume that yellowish hue which characterises boiled fibre.

From the phenomena that are presented by cellular tissue, when exposed to the action of dry and damp air, cold and boiling water, I should infer that it is much sooner acted on by the gastric juice than many others—the muscular tissue for example. The following facts moreover tend to strengthen such an assumption: 1st. Taste which nature has furnished us as a delicate test and safe criterion for judging of the digestibility of food, is much less gratified by the cellular substance that is mingled in our meats, than by the meats themselves; 2dly. I have made this experiment upon myself: when my stomach contains a sufficient quantity of food, I can discharge it at pleasure about an hour after my repast; when it contains but little, I cannot so easily void it, but by distending it with a warm fluid, I am enabled to reject it as well as what was before contained in the stomach. I have frequently ascertained by these means, particularly the last, that cellular masses intermixed with the fleshy fibre of boiled meat, yield more slowly to the power of digestion than the latter, and are scarcely changed while they are reduced to chyme. Fat, which is generally deposited in these cellular lumps, might have tended to the production of this phenomenon; 3dly. I have made the same observation upon dogs, that I have opened during the different stages of digestion, with the view of ascertaining the various states of the bile in the cystic and hepatic ducts, which I have already explained in part. How does it happen then, that the excessive softness and delicacy which characterises the cellular tissue is united with a stronger power in proportion of resisting the different chemical reagents than is found in other tissues of a closer texture?

It is well known that, in drowned persons, a considerable quantity of gas disengaged from certain parts of the body, and particularly vascular parts, as the muscles, glands, &c. distends the cellular tissue, renders it emphysematous, and causes the body to float on the water, &c. This phenomenon does not so frequently occur in open air, where putrefaction takes place so rapidly, with blackness and disorganization of parts. The tendons, fascia, cartilages, bones, &c. of animals drowned, in experiments have never appeared to me to assist in the production of this gas. The cellular tissue itself has, I think, less share therein than any of the above-mentioned organs. It would not, however, be difficult to ascertain the varieties of gas that are produced from each individual organ, by submitting them separately to maceration, in closed vessels, prepared so as to receive these aerial substances. If each have its own peculiar mode of putrefaction, and gangrene, &c.; if in such a state they do not bear the same aspect, it is highly probable that the products which escape from them are as widely different. In bodies that have been buried, and therefore not exposed to air, emphysema often arises, and sometimes to such degree, that the lid of the coffin is burst open, as I have observed myself, although it be loaded with a considerable quantity of earth, and rise above the level of the ground, where other human remains are deposited.

SECTION II.

Parts common to the Organization of the Cellular System.—Blood Vessels.

Injections give us but a faint and inadequate idea of the vessels which belong to the cellular tissue. If they be very fine, and succeed to the utmost, we shall observe a multitude of threads woven in every direction with one another, depriving it of its natural whitish hue, and converting it into a vascular network, often even there is extravasation.

The appearances of the dead body thus injected are very fallacious; they are produced by the mechanical propulsion of fluid in the exhalants; whereas, according to the degree of their sensibility, they rejected the blood in a living state. If we dissect the cellular membrane in a living animal, we shall find that it has the same whitish hue as in the subject, and that large trunks, which do not form any part of its organization, distribute in their course various branches and ramifications, which are obviously lost in this tissue. We distend the subcutaneous tissue by removing the skin from the subjacent organs, and in the middle we may discern various minute branches which terminate in it. This is remarkable in dogs. If we previously inflate the cellular tissue, the experiment will be still more successful. We perceive how the blood varies in these vessels. It frequently happens, when the tissue has been some time exposed to the action of air, that the number of these vessels which existed at the moment of denudation are more than doubled. Wherever we examine any part that is laid bare, we shall find striking varieties in its appearance. In such instances, it is the blood which is engaged in the exhaling vessels, and appears thus to multiply the number of the minute arteries.

Exhalants.

The existence of exhaling vessels is completely established by the following proofs: 1st. By the preceding experiment, which is the natural mode of injecting them; 2dly. By artificial injections, which, as I have just stated, bring a much greater number of vessels into view than can be perceived in the natural state; 3rdly. By the transudations that take place in the cellular tissue when these injections are propelled with much force: transudations that are in effect a species of artificial exhalation; 4thly. By natural exhalation, which is constantly going on in the living body, and borrows its materials from fat and serum; 5thly. By accidental exhalations occasionally taking place when blood is extravasated, and imparts its own hue to serous infiltrations, &c. &c.

Generally speaking, there are few systems in the living economy more abundantly supplied with exhaling vessels than the cellular tissue. I speak not of those designed for its nutrition, which are necessary to it in common with other organs. The redundance of these vessels observes a definite proportion to the habitual exhalation that is there existing. On this particular redundance depends the greater frequency of inflammation in those parts which abound with cellular substance, as we shall see hereafter: it subjects it also in the same ratio to a variety of morbid changes, wherein its tissue, distended with the different substances that are exhaled, is sometimes converted into a solid and compact mass, sometimes into an unctuous and adipose substance; at others it is softened into jelly or condensed into the form and aspect of scirrhus, &c.

Absorbents.

The absorbent vessels correspond to the exhalants in the cellular system; they are imperceptible to the eye, and unattainable by injections. We can, notwithstanding, prove their existence; 1st. By the natural and permanent absorption of fat and serum; 2dly. By the still more striking process by which depositions of fluid are removed from the system in dropsy, of blood in ecchymosis, and in various kinds of absorption; 3dly. The disappearance of mild fluids injected into the cellular tissue, which can only be effected by the agency of these vessels; 4thly. The re-solution of emphysema, natural or accidental, where air, or at least its constituent principles, has no other means for its escape. This is made manifest in the particular instance where emphysema is produced by the rupture of an air-cell in the lungs, or in that, equally in point, where openings that have been made in the subcutaneous tissue of an animal for the purpose of inflation, are found soon after (to avail myself of a peculiar expression) hermetically sealed; 5thly. The drying up of ulcers on the surface, depending, no doubt, on the action of the absorbents of this system. In phthisis often, the suppurating parts of the lungs are suddenly emptied of their contents, and after death, which quickly follows such a change, we see nothing more than the mere cavities which were filled with pus. I have lost two patients in the course of my practice, owing to this sudden absorption of matter, which is precisely correspondent to that which takes place in superficial ulcerations. 6thly. We find the greatest number of absorbents where the abundance of cellular tissue is the greatest, as well as a larger proportion of follicles. In those parts where the tissue is most scanty, as for instance the brain, we observe the very fewest number of absorbents.

The cellular system may be considered then as the main origin of the absorbents, and especially those that serve to convey lymph. These vessels, in union with the exhalants, appear to form the principal part of its texture. Some have the hardihood to assert that it is composed exclusively of them; but such a position has neither observation nor dissection for its grounds. We can distinguish a transparent and filamentous tissue, and nothing more. Each particular cell is an intermediate receptacle placed between the exhalants that terminate in it, and the absorbents that rise from it; they are nothing less than serous bags in miniature: but we cannot observe the orifices of either order of vessels.

Nerves.

Nerves are plentifully distributed about the cellular tissue; but do their ramifications terminate there? It does not appear so from dissection; most probably because these ramifications, white as the tissue in which they abound, cannot be as satisfactorily distinguished from it at their termination as the minute branches of arteries, whose colour, when containing red blood, makes them apparent to the eye.

ARTICLE V.

Properties of the Cellular System.

SECTION I.

Properties of Texture.

The properties of texture are strongly marked in the cellular system.

Extensibility.

The first property which I have occasion to notice is the extensibility of tissue displayed in a remarkable manner in an infinitude of cases, such as œdema, accumulation of fat, and the varieties of tumors where its cells are considerably enlarged and its membranes stretched to an unusual length. No individual natural motion of the body could be performed without this property; the arm could not be raised if the cellular tissue of the axilla did not admit of being increased two or three-fold beyond its usual extent in a state of repose and inaction. The flexion and extension of the thigh, neck, and almost every other part, exhibit the same effect, but in different degrees. If you raise any organ whatsoever, from that directly contiguous to it, the intermediate tissue must be lengthened in proportion. This property is subject to various modifications in the tissue to which it belongs. In the subcutaneous, the subserous, and intermuscular tissues, its limits are much less circumscribed than the submucous, or that, external to arteries, veins, and excretory vessels. Its existence, however, is undeniable in the latter, as is proved by the dilatations of the abdominal viscera, aneurisms, varices, &c. These phenomena themselves, nevertheless, also shew that very little of the property resides in this species of tissue:—the common tissue for instance could not resist the motion of the blood, after the rupture of the arterial coats. If the arteries had no other covering but this, the consequence in such a case would infallibly be a rapid and prodigious dilatation, ending quickly in death. It is the peculiar density of the surrounding sheath that secures the slow and insensible progress of these tumours.

One of the most striking features, in effect, of this property, extensibility, as exemplified throughout almost the whole cellular system where the laminæ, and, consequently, the cells are united, is the instantaneous and unexpected manner in which it is called into operation. We have a very remarkable instance of this mode of extension in emphysema artificially produced, in consequence of which this tissue passes from a state of absolute collapse to the most powerful extension it is capable of attaining. It is the same in artificial injections of fluids of various kinds. After fractures and contusions of the soft parts where swellings of an enormous bulk often suddenly disappear, a similar phenomenon is observable. The cellular tissue is unquestionably the seat of such enlargements as take place under the skin, but in nowise when they occur beneath the fascia, as the principle of extensibility is less active in the latter, and much less easily excited than in the former, and therefore resists such dilatation as is not slowly produced. Many other organs, for example, tendons, cartilages, and bones, having this principle in common with the cellular tissue, are like the fascia, equally slow of dilating. The softness of their original formation may have some influence in modifying their extensibility. The cellular tissue when distended to its utmost, grows thinner, and then breaks. It is impossible for any motion of the frame in the living state, however powerful, to produce a rupture therein. I have remarked, for instance, that it is necessary to exert a force three times greater than that which acts in the elevation of the arm to produce this effect on cellular tissue taken from the axilla. There is, moreover, a species of locomotion peculiar to it which prevents such an accident, so that when it is much stretched, it displaces the contiguous tissue, draws it along with it, and is thus less distended itself. This is strikingly exemplified in enlargements of the testicle, in hydrocele of some bulk, &c. In this case the integuments covering the lower part of the abdomen, the thigh and perineum, are forcibly drawn over the tumour, the covering of which they help to form.

I have remarked that the cellular tissue, when inflamed, loses this property in degree, and is easily ruptured in the dead body. This also happens in the various indurations of which it is the seat,—that portion for instance which surrounds the uterus in a state of cancer, being much enlarged, loses all power of extension, it is even, if I may so express myself, grown perfectly brittle,—the least effort occasions rupture. This is a uniform fact in long established cancers of the uterus and other organs.

Contractility.

The contractility of tissue is brought into action in the cellular system whenever its extension ceases. Thus in atrophy, after the dispersion of œdematous and other tumours, the shells shrink, and lose a great part of the capacity they had acquired,—in wounds too, that involve some portion of the cellular tissue with the skin, the edges do not unite, but a space is left between them owing to the contraction of its cells. The integuments of old people are remarkably flaccid and wrinkled, and especially when they are in any degree emaciated. The subjacent cellular tissue, in effect, loses its power of contraction; the integuments are, therefore, detached from the soft parts and no longer adhere to them. In a young man, on the contrary, however emaciated, the skin continues firmly attached to the muscles, and retains its natural tension, owing to its being brought into close contact on all sides with the parts beneath; the muscles form the outer lines or prominences on different parts of the surface of the body. We must take care to distinguish these prominences which in the face form what is called thin features, from the wrinkles of the skin.

SECTION II.

Vital Properties.

The animal properties do not reside in cellular tissue in its natural state. You may divide it as you will with the scalpel, draw it out in every direction or distend it with gases. The animal, when submitted to these experiments, shews no signs of pain; if any be felt, it is produced from the threads of nervous tissue that supply it, and may perchance have been accidentally injured. In a morbid state, on the contrary, the sensibility of the part is increased to that degree, that it becomes the seat of the most acute pains. We have an obvious instance of this in phlegmonous inflammation. The organic properties are strongly marked in the cellular tissue. Fat and serum could not be removed by absorption, were it not for its organic sensibility which is excited by them into action. I should remark with respect to this property considered in the cellular system, that it is not affected in like manner or degree by all substances. Among the animal fluids, blood, lymph, and milk, whether extravasated or injected, do not augment it sufficiently to prevent absorption, whose system of vessels acts on them in common with fat and serum. This property on the other hand is so far changed by the action of urine, bile, saliva, and other excrementitious fluids, that inflammation is frequently the immediate result, but such a case is never followed by absorption. Amongst extraneous fluids, water injected is absorbed. Wine, and all other stimulating fluids, excite suppuration, and are expelled with the pus. It is well known, that in the operation for hydrocele, abscesses of the scrotum frequently arise from the accidental passage of the injection into the cellular tissue. Experiments on living animals perfectly accord with this fact. All other stimulating fluids, diluted acids, alcaline solutions, &c. will produce the same phenomenon. The existence of insensible organic contractility is indisputably proved in the cellular tissue, by the processes of exhalation and absorption taking place there.

It is a well known fact, that the scrotum contracts in a remarkable manner on the application of cold, that it undergoes different degrees of contraction and relaxation, according as it is stimulated or remains in a natural state; that it contains nothing else but cellular substance under the skin, whose filaments, it is true, have a peculiar aspect, and appear to differ in their nature from those of the other parts of this system. This contraction certainly bears no comparison with that of the muscles; but undoubtedly it is its first degree; it is of the same nature, or rather it is intermediate between them and those insensible oscillations, which are best designated by the name of sensible organic contractibility, by others denominated tonicity, &c.

Sympathies.

The connections between the cellular and the other systems, are numerous and multiplied; but they are not easily detected. In effect, as it is diffused throughout the different organs, and constitutes a portion of their structure, it is difficult to distinguish its properties from those of the parts with which it is mingled. These connexions, nevertheless, are clearly manifested in certain conditions, in acute affections for instance, as well as chronic diseases, it is peculiarly susceptible of the morbid influence of other organs. I would not be understood to speak of such changes as arise from contiguity, or continuity of parts, which, as I have shewed, are sufficiently common, but I advert strongly to those that take place in particular divisions of the cellular tissue, that have no known or acknowledged connexion with the organ affected.

In those acute diseases that are seated in a particular organ, as the lungs, stomach, or intestines, the cellular tissue is frequently affected by the laws of sympathy, it becomes the seat of inflammations, sinuses, &c. Critical abscesses in general, are dependent upon the real though unknown relation that subsists between organs affected and the cellular tissue. The two great properties of this tissue, exhalation and absorption, are frequently deranged in acute diseases, giving rise suddenly to swellings, of an œdematous nature. I attended a patient at the Hospital St. Charles, who, from the effects of excessive terror, was unexpectedly seized with a violent constriction of the præcordia; his countenance, a few hours afterwards, was covered with a saffron hue, indicating the disorder that emotion had excited in the liver. In the course of the same evening, the lower limbs were in an œdematous state, sympathetically produced, no doubt, by the influence of the liver on the cellular tissue. The influence that is exerted by the larger organs of life over this system, is powerfully displayed in chronic diseases, in the derangements that take place in their structure. It is known that the greater proportion of chronic diseases of the heart, lungs, stomach, spleen, liver, and uterus, terminate in dropsy, more or less general, owing to the weakness produced by them in the cellular tissue.

The healing art is infinitely indebted to Corvisa, for having demonstratively shown that almost all infiltrations are symptomatic, and consequently referrible to the indirect influence of the organ affected, over the cellular tissue. In the latter instance, the same effect that was spontaneously and rapidly produced in the patient whose case I have just represented, is slowly and gradually superinduced.

In all acute diseases, we observe that the skin is exquisitely susceptible of the sympathetic influence of disordered or diseased organs, and is alternately dry or moist at the same period, and often in the same day. I am clearly convinced that the cellular tissue undergoes the same changes as the skin, and if the eye could discern them, we should discover its cells at one time, more or less moist, at another, more or less dry, according to the peculiar mode of influence by which it is affected. To this we have, unquestionably, to refer the different state of subjects that have died of acute diseases, and present numberless varieties in the secretion of cellular serum.

Physicians are disposed to consider most symptoms on too broad and general a scale, which are not, properly speaking, dependent (as they conceive) on the disease itself, but flow in various channels from the sympathetic influence of the diseased over the sound organs. The sound organs exhibit according to the manner in which they are affected, various phenomena, essentially foreign to the disease, which renders its features more or less complex, but do not constitute an essential part of it. They occur indefinitely, but in nowise do they influence the disease.

We must remark that, the organic sensibility and contractility of this tissue, are almost invariably excited in its manifestations of sympathy because the two last properties have a sensible preponderance in this system. Sensible organic contractility and animal contractility, are also peculiarly active in the muscular system and its sympathies, according as they belong to the muscles of organic or animal life.

The cellular tissue is not only influenced in its sympathies by the other organs, but it also influences them in turn. In phlegmon, which is a species of inflammation peculiar to this system, the functions of the brain, heart, liver stomach, &c. are successively disordered, if it runs to any considerable height. It gives rise in them to vomitings, redundant secretions of bile, and delirium, which are purely the results of morbid sympathy. In the application of setons, we have a pregnant example of the powerful influence of the cellular system, where its agency is established over other parts. In diseases of the eye, a seton often produces an effect which could not be obtained from a blister; and for what reason? Because there exists a stronger affinity between the cellular tissue and eye, than is observed between the latter and the integuments.

Character of Vital Properties.

From the preceding observations, it is obvious that the principle of life is abundantly developed in the cellular system. In this respect it is far superior to the other organs with which it has been classed, as the fascia, tendons, cartilages, ligaments, &c.—organs that are remarkable for the obscurity of their vital powers and the inertness of their functions. The phenomena of inflammation, for this reason, run their career with greater celerity in this system; their course is very rapid when compared with that of the different tumours which attack the several systems already described.

Suppuration in this tissue takes place with a suddenness of which few organs afford a parallel. We are all perfectly acquainted with the fluid which results from suppuration; its colour, consistence, and its external qualities, constitute a characteristic type, to which we refer the ideas that we conceive of pus; so that, in fact, whatever does not resemble it, is generally held to be of ill quality, or is, in medical phraseology, called sanious. This opinion is decidedly incorrect. Undoubtedly pus which is discharged from a bone or a muscle, from the skin in erysipelas, from the mucous membranes in inflammation, is of a healthy nature whenever inflammation has passed regularly through its several stages, yet it is totally different from the pus that is secreted from the cellular tissue. As the latter is more frequently observed, particularly in cases of surgery, we have formed a

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general idea of laudable as well as sanious or unhealthy pus. In the skin, mucous surface, or the bones, this secretion is vitiated to a certain degree, and differs in the various organs as much as the changes in the vital properties from which it is produced. The changes too in the qualities of this secretion, are as widely different in different organs as the secretion itself.

Does the cellular tissue assume the peculiar modifications of the vital properties which take place in the organs of which it is a subordinate part? From what I have said above, this should seem very improbable. What I have just remarked, is particularly applicable to the cellular tissue found in the spaces between the organs, but not when it enters into combination with them. It is possible, however, that the activity of its vital principle may be diminished in cartilages, tendons, &c. and increased in the skin, and that the same principle may have a tendency in common to harmonize and consort with that of the organs where it is resident. But these are purely conjectures, unsupported by any positive evidence.

One fact, however, we must not pass over here in silence. I allude to the striking difference that exists in the vitality of the cellular tissue, which is composed of layers and filaments almost every where diffused, and that which is entirely filamentory, and lies external to mucous surfaces, blood-vessels, and excretories; a difference that explains the scarcity of inflammations and tumours in the latter. It is frequently an insuperable barrier to the diseases of the former, and thus defeats the organ it encloses. As a proof of this, I have often observed in dissections post mortem, that while the common tissue in which the arteries are buried are in a state of absolute suppuration, as in the axilla, that constituting the outer sheath of the vessels is perfectly sound. I have witnessed the same appearance in the tissue surrounding the ureter in the psoas abscess.

SECTION III.

Properties of Re-production.

The cellular tissue is distinguished from the other organs by the faculty of engendering living substances, of extending and re-producing itself; in a word, by the principle of growth it enjoys whenever it has been cut or divided in whatsoever manner: on this faculty depends the formation of cicatrices, tumours, cysts, &c.

Influence of the Cellular Membrane in the Formation of Cicatrices.

Cicatrices may be considered under a twofold aspect: 1st. In external organs, and particularly the subcutaneous tissue and skin; 2dly. Internal organs. I shall first notice those that are produced externally. Every wound that goes through its particular stages exhibits the following phenomena in the interval of its formation, and the period of cicatrisation; 1st. It inflames; 2dly. It forms granulation from its surface; 3rdly. It suppurates; 4thly. It contracts; 5thly. It is covered with a thin and delicate skin, red at first, but afterwards of a whitish hue, becoming white at different stages.

First Stage.

The instant that a wound is received, inflammation takes place. It is the unavoidable offspring of the irritation that is excited by the instrument that produces it, contact of air, accidental particles of dress, or surrounding substances. Before the accident, the greater proportion of these parts involved in the breach of continuity being unexposed, possessed only organic sensibility, but afterwards these same parts concurring to form the surface of the body, have animal sensibility superadded to it, or that principle which transmits received impressions to the brain; the effect then of inflammation upon organs endued only with the first kind of sensibility, is to exalt it to such a degree, that it is placed on an equal footing with the second, and like it receives the faculty of transmitting perceived impressions to the brain.

A consequence resulting from this, is, that parts divided by a wound, are thereby enabled to fulfil the functions of integuments: this is unquestionably the first advantage derivable from the inflammatory state of cicatrisation.

But there is another advantage attendant on this stage—that it prepares the parts for the developement of granulations, in fact, granulation always precedes such developement; thus the excess of vitality, that is produced in our organs, appears absolutely necessary to stimulate these parts that are to be re-produced. By these means the cellular tissue, from which granulations sprout as their bed, is imbued with more sensibility and more insensible contractility. It assumes a temperature exceeding that of the neighbouring organs; it becomes the centre of a small circulating system, independent of that of the heart. It is in the midst of this exuberance of life that granulations have birth and growth, to whose production the ordinary amount of vital activity would have been insufficient. Hence the pale hue, the flaccidity of those bodies, when the functions to which they owe their existence are weakened or destroyed.

Second Stage.

The growth of granulations succeeds to inflammation, and is attended with the following phenomena: small florid excrescences spring up in the form of irregular tubercles unequally scattered over the surface of the wound; they are not fleshy as the name they bear, (bourgeons charnus) owing no doubt to their colour, might seem to import. They are but small vesicles, full of a thick, and, as it were, unctuous substance, which is hitherto unknown, and ought to be submitted to chemical analysis. The cells are so replete with this substance, that if we inflate the tissue subjacent to a wound, either in the dead or living animal, the air cannot be made to penetrate the granulations. The whole mass of them will be raised from the surface, but not one undergoes that distension and increase of calibre which the cells do that are void of this substance. The granulations remain the same amid the general tumefaction of solids. I have repeatedly made trial of this experiment on animals that I had expressly wounded for this purpose.

Gradually as granulations complete their growth on a bare and exposed surface of cellular tissue, they are seen to unite, to adhere together, and constitute by their union a sort of provisionary membrane, which excludes the contact of air from the subjacent parts, while the true and permanent cicatrix is beginning to form. This provisionary membrane of wounds, this species of epidermis, which is furnished expressly for the protection of these parts during the process of cicatrisation, differs from the ordinary serous membranes in respect that the latter have smooth and polished surfaces, while that of the former is irregular and tuberculated, from the granulations with which it is sprinkled. This irregularity of the granulations, together with their insulated state, may at first appear incompatible with my manner of explaining the early formation of the cicatrix; but the following experiment is sufficiently conclusive of this question. I inflicted a large wound on an animal, and allowed it to run through its various stages, after which it was killed. I removed that part of the flesh which was covered with granulations, I stretched it out on a prominent body, so as to give the utmost convexity to the granulated surface, which in its natural state is concave; the tubercles then disappeared, and the provisionary membrane of which I have spoken, being drawn out, it might have been mistaken for an inflamed serous membrane.

From thence it follows, that as soon as granulations are united the air is denied all access, and what has generally been asserted of its contact is contrary to truth and to the laws of nature, who is better skilled than we are with our external coverings, in protecting the divided part at the commencement and during the progress of cicatrisation.

Such are the general phenomena of this process externally, during the two first stages of its formation. Internally, it approaches with certain exceptions to the same state. Thus it is easy to prove, that in the latter case, the cellular tissue performs an important, and, I may say, an exclusive part, and that all these phenomena take place in that tissue or its cells. The following observations indisputably establish the cellular nature both of the granulations and of the adventitous membrane that they form: 1st. In those parts which are abundantly furnished with cellular tissue, as in the cheeks, granulations are most readily produced and wounds soonest heal; 2dly. The skin, when deprived of too much tissue, is slow in throwing out these bodies, and is therefore not easily united with the neighbouring parts. Hence the precept so strongly recommended in surgery, that we should be sparing of that tissue in dissections of tumors, extirpations of wens, cysts, &c.; 3dly. Maceration in the subject always reduces the surface of granulated wounds to this primitive basis; 4thly. The nature of granulations is every where the same, be the organ that produces them what it may, whether muscle, cartilage, skin, bone, or ligament, &c. The only difference exists in the relative quickness of their production, which is regulated by the activity of life, with which each organ is pregnant, and the developement of the vital powers. In the skin, for example, they make their appearance within four or five days, whereas, in bones they occur at a much later period of time; but their texture, external appearance, and nature, are always the same; consequently, they are the growth and expansion of an organ common to all other parts; and accordingly, this organ, common to all other parts, and the universal basis of our living fabric, is the cellular tissue.

The reddish colour of granulations has led to an opinion that they were produced by enlarged blood vessels, but their developement is entirely independent of the vascular system. The following explanation is illustrative of my dissent from such an opinion: We have already seen that the cellular tissue is fraught with exhalants and absorbents, so that it appears almost entirely formed of them. We shall find then on further investigation, that in inflammation red blood is perpetually forcing itself into these species of vessels, and that as granulations are formed of and by cellular substance, they consequently partake of the nature of that system; on the other hand, being constantly in a state of inflammation we can easily conceive that the redness of granulations is like that of an inflamed pleura of the cellular tissue in a state of phlegmon, or the skin affected by erysipelas. Nevertheless, it does not imply any elongation of vessels carrying blood, but simply the propulsion of blood into those that carried serum. This is so true, that when inflammation is at an end, and the blood ceases to be admitted into these vessels, the membrane recovers its natural hue, and the granulations in the same manner lose their red colour altogether after cicatrisation has taken place, because the blood no longer penetrates them. If, on the other hand, there had been any new production of vessels, they would have continued to exist and perform their functions. Besides, how can we admit the developement of blood vessels in those parts where none originally existed, for example, in tendons, cartilages, &c. which, like other parts, when divided, are capable of producing granulations.

From the above considerations it must be inferred that the arterial system has no share in the formation of granulations, and that the cellular tissue is its exclusive agent, inasmuch as that tissue alone has been endowed with the singular property of extending, multiplying, and re-producing itself.

This then briefly is what takes place in the second stage of the cicatrisation of wounds. The cellular tissue, having acquired an increase of sensibility in the first stage, rises into an indefinite number of vesicles, that are scattered here and there, exhale a whitish substance, but little known, unite at their superficies and form a provisionary membrane. But how is this membrane converted into that of the cicatrix? Let us follow nature who arrives at this stage by the two final ones of inflammation and cicatrisation.

Third Stage.

There is no stage of suppuration in the cicatrising of bones, in that of divided cartilages, lacerated muscles, and rarely in the union of most organs divided without an external wound. It is necessary then, in the first place, to shew what relation subsists between these cicatrices and those of external organs; for one individual principle is found to preside over all the operations of nature, differ, as they may, in their outward form and aspect.

In a fractured bone, the two first stages of its union are precisely the same as those of external organs, the ends inflame and are covered with fleshy granulations: in the third stage these granulations previously united assume the nature of a secreting or rather an exhaling organ, which at first separates the gluten that surrounds it, and gives the appearance and character of cartilage to the callus, afterwards effuses phosphate of lime, and subsequently completes its transformation into bone. In the cicatrization of cartilages, gluten, in divided muscles, febrine is exhaled; in a word, the cellular tissue is the common basis of the healing process in all internal organs: as granulation is every where the same, the process by which the wounds of internal organs are repaired is alike in all through this basis, and the only difference that is found between them exists in the fluid that is separated and remains in the cellular tissue. This fluid is in general the same as that which serves for the nourishment of the organs, and that which is taken to and from it in the performance of that function, accordingly, as each organ in the different systems has its own peculiar nutritive principle, so, each must have its peculiar mode of union. We should be as conversant in the cicatrisation of the different parts as we are in that of bones, if the substances that nourish them were as thoroughly known to us as jelly and phosphate of lime: the manner in which cicatrisation takes place in internal organs is generally analogous to that of nutrition, or rather it is the same, with this sole difference, that the cellular tissue shooting out into irregular granulations on the divided surfaces, does not of necessity correspond to the figure of the organ that it serves to unite. Hence the irregularity of callus, &c.

Such are the phenomena of the third stage of cicatrisation in internal organs, and closely do they resemble those that are manifested in the external organs, the membrane covering the granulations becomes also a sort of exhaling organ that separates a whitish fluid called pus from the blood; but there is this difference, that instead of remaining in the substance of the granulations, instead of penetrating, incrusting, and consolidating this substance, as the phosphate of lime and gluten penetrate and encompass the bones, it is expelled as extraneous matter, and in nowise conducive to their union; so that in the internal organs, first exhalation, and then consolidation, of the exhaled fluid takes place, and in the external parts, exhalation and afterwards excretion of that fluid.

To conclude, an internal wound that involves the cellular tissue and suppurates, seems to me perfectly analogous to the serous surfaces, which in consequence of inflammation are covered with a purulent exudation. The thin pellicle that lines the granulations, is of the same nature as the pleuræ or peritoneum when inflamed, that is to say, essentially of a cellular nature. Pus in both cases is nearly the same, and resembles that in phlegmon, whereas if the skin only is affected, this fluid is totally dissimilar in its nature, as is observed in erysipelas. The exhalation of pus on the surface of a wound, and that of divided membranes, appears to me to hold considerable analogy with that of the white matter that is contained in certain cysts.

Fourth Stage.

Suppuration exhausts by degrees the whitish substance that fills the granulations; their cells, at first much expanded, lessen gradually in bulk; they collapse by means of their contractility of tissue, adhere together, and the following are the phenomena that result from their union. 1st. The granulations disappear and are re-implaced by a uniform surface; 2dly, that surface is a thin membrane, because the size of the granulations depends not on the cells, but on the substance they contained, which is absorbed ; 3dly, this membrane is shrunk, and infinitely of smaller diameter than the original membrane which covered the granulations, because the cells as they contracted draw the edges of the divided parts from the circumference to the centre, which are thus shortened, and the size of the wound materially lessened; the same granulations which at first occupied a space of six inches in diameter, as in the operation for cancer, are reduced to little more than an inch and a half.

When adhesion is completed between all the cells that originally formed granulations, the membrane of the cicatrix exists that results from such adhesion : thus these fleshy substances, whose developement surprised us, and which appeared amply to repair the loss of substance, are reduced to nothing more than a mere pellicle, of a reddish hue, as long as the exhalants are filled with blood, and afterwards white, owing to the return of this fluid to its natural channels.

From this mode of origin that is observable in the cicatrisation of superficial parts, it is obvious to remark, 1st, why they so intimately adhere to those parts where they are formed, and never have the looseness of the common integuments; 2dly, why the skin is drawn together from the neighbouring parts to cover the wound; 3dly, why it wrinkles in approaching the wound; 4thly, why in those parts where it yields the most, as the scrotum and axilla for instance, the cicatrix is the least extensive, &c.; why, on the other hand, it should be much more limited in extent where the skin does not yield with equal facility, as in the sternum, cranium, and trochanter major, &c.; 5thly, why the thickness of every cicatrix is invariably in the inverse ratio of its extent; in fact, as there are uniformly the same number of granulations that unite together to form the cicatrix, we cannot deny that what it gains in one way it loses in another, whence there results, that those which are of considerable extent are easily ruptured; 6thly, why they have no regular organization, do not partake of the functions of the cutaneous organ that they re-implace, and why their texture is absolutely distinct from that of the latter organ.

The cicatrisation of wounds abandoned to the care of nature, and especially when there is waste of substance, differs materially from their union by the first intention, which is ascertained from the agglutination of their edges: the reason of this difference is, that in the latter there is neither the second stage, the growth of granulations; nor the third, which is that of suppuration; nor the fourth, which is that of contraction. Union immediately follows the first stage, namely, of inflammation.

From what has been above stated, it is manifest that the cellular tissue is the essential agent in the production of the cicatrix; that it constitutes both its basis and its inherent principles; that without it it could not take place; and that it is essentially dependant upon the property of growth and expansion with which that tissue is endowed.

Influence of the Cellular Tissue in formation of Tumours.

In the formation of the cicatrix, the cellular tissue seldom rises above the level of the divided part more than a few lines; the cells that it forms in its re-production are, generally speaking, very inconsiderable in their magnitude. This however is not the case when it happens to deviate from the ordinary laws of cicatrisation, and some accidental cause perverts and vitiates its vital properties; it is then observed to shoot forth very extensive granulations, and which often contain greater abundance of this tissue than the parts from which they spring. All the various excrescences understood by the names of fungus hypersarcosis, medullary sarcoma, &c. are nothing more than the result of this exuberant growth of cellular tissue, which has exceeded its usual limits in the process of cicatrisation ; accordingly, the cicatrix cannot be formed of these productions, nor can consolidation take place till they are suppressed. But it is in different tumours especially that we observe this developement of cellular tissue. The fungous tumour, a species of production that strikes root exclusively in the mucous membranes, sinuses, fossæ, nasali, mouth, and especially in the uterus, and which differs strikingly from such tumours as have their seat in the fibrous membranes, as the dura-mater for instance, although they are comprehended under one common denomination, all fungus excrescences, I say, are composed of cellular tissue, and have moreover a peculiar matter deposited in their cells, which, according to the quantity in which it is secreted, leaves its primitive basis more or less exposed.

The polypus, whether of the mucous or sarcomatous kind, a species of tumour that belongs to the mucous system, has the cellular tissue also for the primitive basis of its organization. The different modifications of cancer manifest this more or less strikingly, by the enlargement of the parts which they occasion. It would be necessary to run through the whole classifications of tumours to point out those to the formation of which the cellular tissue contributes.

We may then consider the cellular tissue as forming the general basis, the parenchyma of nutrition of almost every excrescence; first it shoots and grows over the part where the tumour is to be formed, and afterwards incrusts itself with divers foreign subtances, the different nature of which constitutes the diversity of tumours. These phenomena are perfectly analogous to those of common nutrition. In effect, all organs resemble each other in their nutritive basis, their parenchyma of nutrition, which is vascular and cellular; they differ from each other in the nutritive substances that are deposited in this parenchyma. In like manner all tumours are cellular. It is their common character. Their individual character is derived from the substances separated by the tissue accordingly to the morbid alterations of which it is the seat, modifying in various ways its vital powers, and placing it in connection with such and such substance. Thus, as it has already been stated, all internal cicatrices resemble each other in their first stage, presenting differences, in proportion as they become impregnated with the nutritive substance of the organ to which they belong.

From these principles it is obvious how very regular nature is in her operations, how an uniform law envelopes the whole, and how the applications only of that law differ from each other. Wherever nutrition is affected, or an accidental modification in this function takes place, the cellular tissue acts an important part; for this it is indebted in the process of cicatrisation, and formation of tumours, to the singular property it is endowed with of extending, dilating, and growing. If all the tumours that are formed over the muscles, tendons, cartilages, &c. be examined, no expansion of the fleshy, tendinous fibres, or of the cartilaginous substance, &c. will ever be discovered; the cellular tissue only shoots from the organ and plunges into the tumour. Thus, in order to form granulations, the fibres of bones, muscles, and of fibrous substances, divided by a solution of continuity, never extend beyond the level of the wound, as in the cellular tissue of the part.

The tumours I have just mentioned have nothing in common, as may easily be conceived, with the acute tumefactions that constitute phlegmon, nor with those congestions that occur in the limbs where there has been violent irritation; as in fracture, complicated laxation, whitlow, puncture, with a venomous instrument, congestions that in general arise around the external part, violently affected, that sometimes come on almost instantaneously, are not in reality inflammatory, although there is tension, pain, &c. and which better deserve the term of inflation than than of congestion.

Neither should these tumours be confounded with certain chronic congestions, in which the cellular tissue, without growing or increasing in the least, is infiltrated and impregnated with divers substances that alter its nature; such are those that occur in the diseases of the articulations, the callosities of fistulas, &c., the greasy matter found in certain tumours, &c. In all these cases there is no addition or growth, as in a polypus, a fungus, &c. It is a substance more solid than serum, infiltrating the cellular tissue, and forcing its laminæ, so as to give the whole mass an homogeneous appearance.

Besides, there is at the instant of death, a remarkable difference between an acute and chronic tumour, whether this last is produced by a growth of the part, or by infiltration: in fact, it remains the same, and retains, like every other organ, its volume, form and density, until dissolved by putrefaction. The first, on the contrary, as I have observed, subsides with the decay of the vital powers: this varies. If the tumour is nothing more than the cellular distention I have just mentioned, and which is so frequent in external injuries, it totally disappears; if, besides this swelling, there is an accumulation of blood, as in carbuncle, phlegmon, &c. a portion of the tumour remains, but its bulk is always considerably diminished. In general, it is upon this swelling, the immediate cause of which is not known, that the abatement of the tumour especially depends. Let us proceed to another function, not less important, of the cellular tissue, and which is very analogous to this.

Influence of the Cellular Tissue in the Formation of Cysts.

We understand by a cyst, a membrane in the form of an unperforated sac, which is accidentally developed, and which containing fluids of a different nature, has on that account been divided into different species. Cysts are essentially formed at the expense of the cellular tissue; they originate amidst its cells, expand in every direction amongst them, and borrow all their characters.

To be convinced of the influence of the cellular system in the formation of cysts, it is sufficient to prove, that between them and the serous membranes there is the greatest analogy, and even almost identity; for we shall find that these kinds of membranes are essentially cellular. The following are the analogies between these two kinds of productions, the one of which is natural, the other accidental.

1st, Analogy in confirmation. Every cyst forms a kind of imperforated sac, containing the fluid that exhales from it, exhibiting a smooth and polished surface contiguous to this fluid, another rough, flaky, and continuous with the adjacent cellular tissue.

2dly. Analogy in structure, cysts being always formed of a single sheet, as the mucous membranes have all, like these, a cellular texture, which is proved by inflation and maceration. Thus, they arise constantly in the midst of the cellular organ, particularly where it is most abundant. They are scantily provided with blood vessels, and are strongly characteristic of the exhalent system.

3dly. Analogy in the vital properties. Animal sensibility, though not present in the natural state, is very active in inflammation, organic sensibility always very obvious, firmness characterised by a slow and gradual contraction subsequent to the evacuation, either natural or artificial of the contained fluids, &c. Such are the characters of cysts: they also appertain, as we have had occasion to mark it, to the serous membranes.

4thly. Analogy in functions. Cysts obviously are the secreting or rather the exhaling organ of the fluid they contain. Exhalation is particularly striking, when, subsequently to the evacuation of such fluids, the removal of the membranous bag, or the producing artificial inflammation, has been neglected. Absorption manifests itself in the spontaneous cure of incysted dropsies, a cure in which this function can exclusively concur.

5thly. Analogy in the affections. Who is not aware that, between the dropsy of the tunica vaginalis and the encysted dropsy of the spermatic cord, there is the utmost analogy; that the curative means are the same, that the events are similar, that in both cases the inflammation created by the injection of a foreign fluid, of wine for instance, is the same, and effects a cure by a similar mechanism? If we open two subjects, each afflicted with one of these diseases, and compare the state of the two bags in which the fluid had gathered, their aspect will be perfectly the same. Deprive the cyst in the melliceris of the fluid it contained, and but little difference will be observed between the hydropical cysts and serous membranes.

The preceding considerations naturally lead us to establish a perfect similitude between cysts and serous membranes, the properties of which they partake, and into whose system they enter essentially, as well as into the cellular system. It is highly probable there exists a consent between the one and the other, and that when a cyst unfolds and supplies a more abundant exhalation, that of the serous membranes is diminished: however this is not supported by direct proofs. Here an important question naturally presents itself, namely, how cysts unfold; how a membrane that does not exist in the natural state can arise, increase, and in particular circumstances, even acquire a very considerable expansion. This problem is generally resolved in the following manner: at first a small quantity of fluid gathers in one of the cells. This fluid increases, dilates the cell in every direction, its parietes adhere to the adjoining cells, and thus its thickness is increased. By degrees this fluid, which is serous in dropsies, whitish and thick in steatoma, &c. increases in quantity, expands in every direction the bag that contains it, enlarges and compresses it against the neighbouring organs, and gives it the form in which it appears. Nothing at first glance is more simple than this mechanical explanation; nothing however more distant from the process of nature. The following considerations will aid the proof of this: 1st, Cysts are in every respect analogous to serous membranes. Why then should their mode of origin be different from that of these membranes, which, as I shall prove, are never formed by the compression of the cellular tissue? 2d, Does so mechanical an origin, where the vessels compressed against each other must unavoidably be obliterated, as is seen in the skin when it has become callous, accord with the functions of exhalation and absorption of cysts, with their peculiar mode of inflammation? 3d. How can it be accounted for, that, if the cells compressed and cemented together, form the unnatural bags, the adjacent cellular tissue does not diminish, and even totally disappear, when they attain a considerable size? 4thly, If on the one hand cysts are formed by a compression of the cellular tissue, if on the other hand it is true (which cannot be doubted) that they exhale their own fluid, it must be admitted that the fluid pre-exists in the organ by which it is separated from the blood. I would almost as soon assert that the saliva pre-exists in the parotid gland, &c.

I am induced to think, that the immediate consequence of the preceding reflections infers, that the manner in which the formation of cysts is generally accounted for, is diametrically opposite to the general process which nature follows in her operations. How then do these sacs arise and increase? In the same manner as all tumours that we see arising externally, or manifesting themselves within, for there hardly exists any other distinction between these two species of unnatural productions, but the form each assumes. The major part of tumours expel through their external surface the fluid separated by them. In the cyst, on the contrary, that fluid is exhaled through its internal surface, and is deposited in its cavity. Only suppose a fungous tumour in a state of suppuration suddenly converted into a cavity, and pus leaving the external surface to invade the parietes of that cavity, and it will form a cyst. In like manner, suppose a superficial cyst, whose cavity is obliterated, and the fluid transuding through its external surface, and we shall find a suppurating tumour.

Since then, form only constitutes the difference between a tumour and a cyst, why should not the production of the latter be similar to that of the former? Besides, have we ever imagined that the formation of external and internal tumours can be attributed to compression? It is necessary then to conceive that cysts are produced in the following manner. They first originate and are developed in the midst of the cellular organ, by laws very similar to those of the general growth of our parts, and which appear to be aberrations, unnatural misapplications of these fundamental laws with which we are unacquainted. When once a cyst is characterized, exhalation begins at first sparingly, and subsequently, it increases in proportion to its progress. The growth of the exhaling organ then invariably precedes the accumulation of the exhaled fluid, in the same manner as in other cases, the quantum of suppuration in a tumour is in a direct ratio to its bulk.

ARTICLE VI.

Developement of the Cellular Tissue.

SECTION I.

State of the Cellular System in the early Stage of Life.

In the early stage of conception, the embryo is nothing more than a mucous mas, apparently homogeneous, and in which the cellular tissue seems almost exclusively to predominate. In effect, as soon as the organs in this mass begin to unfold, the interstices they leave between them are filled with a substance perfectly similar to that which previously composed the whole body, and may be considered as the remainder of it, or rather as existing in a distinct manner, because it has not been impregnated with a peculiar nutritive substance, like that which forms the nutritive parenchyma of the organs, and which before this impregnation was perfectly similar to it. This substance interposed between the organs, and which forms the rudiments of the cellular tissue, recedes so much the more from the fluid state in proportion as the time of birth draws near. At first it represents actual mucous, subsequently a kind of glue, and finally the cellular texture begins to manifest itself.

This primitive state of the cellular organ, this appearance displayed in its early stage, are owing to the astonishing quantity of fluid with which it is at that time imbued, and by no means denotes an unorganised state: it may then be compared to a vitrified body, which at the first glance appears quite fluid, because the transparency of its laminæ do not allow of their being distinguished; puncture them however so as to evacuate the humour, and they appear.

Thus is the cellular tissue observed to be remarkably thin, and actually transparent at that tender age, concealed by the humour it is filled with, and becoming gradually more apparent as this humour insensibly diminishes with age. This phenomenon is sometimes re-produced at a subsequent period, whenever the different serous infiltrations occur, particularly when the infiltrated fluid has a certain degree of viscidity.

What can be the nature of that humour the cellular system is so liberally supplied with in the early stages of conception? Is it of an albuminous nature, like that intended to lubricate it at a future period? This is highly probable. But I am also inclined to think it has much of the gelatinous character, a character which strongly predominates in the animal fluids (as it is well known) at that period of life. I have no experience on this point; whatever this humour may be, it is by far more viscous and unctuous than will be found at a further period. To be convinced of this the touch is sufficient. To its predominance and the excessive tenuity of the laminæ is owing, that all attempts in the early months to create emphysema in the fœtus, by forcing air under the skin, is hardly ever attended with success.

At birth, and for some time after, the great proportion of subcutaneous fat renders it very difficult to produce an artificial emphysema; it does not appear that the fœtus is ever affected with emphysema naturally. Such at this period is the fineness of the cellular layers and filaments that the imagination cannot depict them, the texture of the hair is coarse in comparison. I presume that the mass of fat which I have stated almost always to exist in the cheeks of the fœtus, proceeds from the rupture of several layers, whence a large cell, which fills with adipose matter, is produced.

Some time previous to birth, at that period, and in the ensuing years, the cellulary humour gradually decreases; the cells become drier, consequently more distinct; the total mass of the cellulary system lessens, because as the organs gradually increase in bulk, the spaces they leave betwixt them grow narrower; however, this system predominates for a considerable time: from whence proceed the peculiar forms which characterise the infant; the slight projection of his organs, which by this cause are disguised; from thence partly the suppleness and multiplicity of his motions; from thence also proceed the frequent diseases to which at this period he is liable.

The laminæ still continue excessively thin; they are still very apt to be torn. In producing emphysema in very lean infants, I have observed that considerable dilatations frequently take place in different places, a kind of pouches where air accumulates in a considerable quantity, and which only proceeds from such lacerations, whilst in the same experiment in the adult, the air is uniformly diffused, and fills the cells regularly without causing them the least injury. In comparing in our butcheries the veal that has been inflated with that of oxen in the same state, I have sometimes been led to make the same observation.

In infancy and in youth, the vital energy of the cellulary texture is particularly striking; at that age the granulations, which are essentially cellular, as we have seen, arise with greater rapidity, and go through their usual process in a shorter time than at any other age. The lips of wounds unite more readily, and every tumour in its developement and course bears a stamp of rapidity which proceeds especially from the high degree which the vital forces of the cellulary system have attained in the infant. To the same cause must be attributed the facility in the re-absorption of the serous fluid, which sometimes accidentally infiltrates the cells, as it is observed in the scrotum, in the eyelids, &c. the disposition to form cysts, &c. then dropsies, are much less frequent. When they take place, why are the superior limbs almost as frequently affected as the inferior whilst it is generally in the latter that the leuncoplegmacy begins in the adult? The singular tendency that the legs have to œdematous swelling is even then a remarkable occurrence. Might not this proceed from the position, which compelling the lymph to rise contrary to its gravity, weakens, by degrees, the absorbents, when it has existed for along time? This fact seems to coincide with that of various affections, which (as is well known) are much more frequent in the inferior than in the superior extremities.

SECTION II.

State of the Cellulary System in the following Ages.

In the adult the cellulary membrane condenses, and acquires firmness; its laminæ acquire a lighter texture; its quantity also seems to lessen, because the bulk of the organ being increased, their interstices become narrower. If there is not an actual diminution, at least there is one in respect to the state of the organs. To this circumstance must we attribute the projection of these beneath the integuments, the power of muscular forms, &c. It seems, however, that the quantity of the cellular membrane varies according to the temperament; that in those which are denominated phlegmatic or lymphatic, it is more abundant than in the other systems; that on the contrary, in such subjects as are called bilious, which characterises (as is said) the dry and rigid, it is in a smaller proportion. In the female it seems to be in a larger quantity than in the male; the delicacy of form is in the fair sex partly the result of its predominance. The motion of one part does not seem to produce a more active nutrition in its cellular texture, as is the case in respect to muscles, to nerves, and even sometimes to blood vessels.

In old age this tissue condenses and contracts; it acquires a considerable consistency and hardness, and the tooth tears it with difficulty in the boiled meat of old animals. In these it is tough, and requires a very long ebullition to dissolve it: much less fluid is exhaled within it; on which account there is a kind of stiffness and rigidity which renders the motions of old age rather difficult. This kind of decay is particularly connected with the general disunion which the body at that time undergoes. It loses its vital forces; from thence its relaxation, which does not allow it to sustain the skin as usual. This becomes slack every where, being even pendent in some parts where it forms wrinkles. The scrotum has no longer that power which characterised it, of contracting, and which it borrowed from the energy of the cellulary system. That general relaxation, that kind of flaccidity, is the constant badge of old age, even with those in whom this has been produced prematurely by every kind of excess, or by original disposition. I have seen a dwarf at the medical society, aged sixteen years, and somewhat more than two feet in height; he was already growing old, and his subcutaneous tissue exhibited that laxity which at that age is never to be met with. The same phenomenon was exemplified in the King of Poland's dwarf. Two persons who had lived with him a long time, have informed me, that at his death he exhibited in his exterior habit that relaxation and that flaccidity of the integuments, of which the subjacent cellular tissue appears to be an essential seat.

It is rare that in the latter age bony incrustations take place in the cellulary membrane. In the great number of aged subjects that I have already had an opportunity of dissecting, or caused to be dissected, I remember to have seen but one instance where it occupied the posterior part of the mesentery. In adults, particularly in women, where they occur pretty frequently, in the cellular tissue which separates the womb from the rectum, I have seen others, of which I preserve different examples.

NERVOUS SYSTEM

OF

ANIMAL LIFE.

Anatomists, till now, have considered the nervous system in an uniform manner; but however little we reflect on the forms, the distribution, the texture, or the properties and uses of the divers ramifications of which it is composed, it is easily perceived that they should be referred to two general systems, essentially distinct from each other, and having for principal centres, the one the brain and its dependencies, the other the ganglions; the first appertains especially to animal life; on one hand it is the agent which transmits to the brain the external impressions calculated to produce sensations; on the other hand it serves to convey the volitions of that organ which are performed by the voluntary muscles to which it resorts. The second, almost invariably distributed to the organs of digestion, of circulation, respiration, and the secretions, depend in a more particular manner upon organic life, where it acts a more obscure part than that of the preceding. Neither of them are strictly limited to the organs of either of these lives. Thus the cerebral nerves send some ramifications to the glands, the involuntary muscles, &c. In like manner the nervous system distributes some branches to the voluntary muscles. It is upon the general disposition and the abstraction of particular exceptions, that the division of the two nervous systems is grounded, between which I do not intend to draw now a distinctive line to establish their difference, because the simple exposition of each is sufficiently demonstrated.

The nervous system, like all the organs of that life, is exactly symmetrical. The brain and the medulla oblongata, which are the double sources of this system, exhibit this character in an eminent degree. Nerves exactly alike start from each of them; from thence the appellation of pairs, by which the double corresponding trunk is described, a term which generally cannot be applied to the system of ganglions. There are then two nervous systems in animal life, the one on the right, the other on the left side; they are separated by the median line. This distinction is apparent, not only in dissection but likewise in diseases; at times one lateral half of the body is perfectly deprived of motion, and the whole of one lateral nervous system is reduced to a passive state, the other being in activity as usual; sometimes the system on one side assumes a degree of energy contrary to the laws of nature, and becomes the seat of convulsions, whilst the other remains perfectly calm; in both cases the phenomenon is sometimes general. It is often confined to one or more of lateral organs; but always draws a distinctive line between the two nervous systems, right and left. The kind of partial palsy I have just mentioned, and whose principal character results from the symmetry of the nervous system of animal life, is perfectly distinct in this respect, from that in which the inferior part of the body is deprived of motion, by a fall upon the sacrum, or by any other similar cause.

The proportions of size between the nervous system and the brain, in respect to man and the greatest part of quadrupeds, are, as Sœmmering has observed, in a reversed state. In the first, the brain is much more voluminous than in the others, whose nerves are much more remarkable for their bulk than in man. In all animals generally submitted to our experiments, it is easy to verify this observation; it is even on this account that small dogs are very fit subjects, owing to the size of their nerves, for nice experiments upon sensibility. This difference is a striking sign of the superiority of man in respect to intellectual phenomena, all of which refer to the cerebral mass. Many animals, on the contrary, are superior to him in respect to motions, and the four senses of taste, smelling, hearing, and sight. It is to be remarked, however, that in the perfection of the fifth sense, that of touch, he excels them all. Why ? Because this sense is quite different from the others, that it is consequent to them, and rectifies their errors. We feel, because we have seen, heard, tasted, or smelt the objects. This sense is voluntary; it supposes reflection in the animal which exercises it, whilst the other four require none. Light, sounds, &c. strike their respective organs unnoticed by the animal, whilst he will feel nothing without a preliminary act of the intellectual functions. Is it not then astonishing, that in man the perfection of the organs of touch, and the extensive developement of the brain, should be in the same proportion, and that in animals where the brain is more contracted, feeling is more obtuse, and its organs less perfect.

ARTICLE I.

Exterior Forms of the Nervous System in Animal Life.

I shall consider these forms ; 1st, In the origin ; 2dly, In their course ; 3dly, In the termination of the cerebral nerves.

SECTION I.

Origin of the Cerebral Nerves.

The word origin must only be understood in respect to the anatomical disposition. In fact, on one hand nerves are formed at the same time as the brain; they are rather the organs of communication with that viscus than its real extensions. On the other side, if we consider the functions of a part of the nervous system with that which relates to sensations, we shall see that it terminates in the brain, and that the origin is exterior. Is it not said that the nerves proceed to such and such a part, that the arteries run, wind, &c.? These are nothing more than so many metaphorical expressions, of which the least reflection suffices to rectify the sense.

The nerves of animal life have their origin in three principal portions of the cerebral mass; 1st, From the brain; 2dly, From the tuber annulare, and from its extensions; 3dly, From the spinal marrow. The cerebrum produces none. This circumstance, which should not be overlooked, in examining the functions of each part of the brain, and which may perhaps, one day or other, throw a light on the difference of these functions, is sufficient to make us appreciate the opinion of several physicians of the last century, who fixed the source of the involuntary motions in the cerebellum, and attributed the voluntary ones to the brain. The brain supplies but two nerves, the olfactory and the optic. Both are remarkable; 1st, Because their attachment at this origin from the brain is strongly marked, and on removing the pia-mater they can never be carried off; 2dly, They are much softer than the greater part of the other nerves. The tuber annulare, and its extensions, including those that proceed to the brain, that go to the cerebellum and that which begins the spinal marrow, furnish the general motors of the muscles of the eye, the pathetic, whose origin, although posterior, is evidently from the corpus annulare, the trigemini, the motor externus of the eye, the fascial nerve, the auditory, the par vadum, the glosso, pharyngeal, and the great hypoglossal. All these nerves are remarkable for distinctive characteristics.

1st, As the medullary substance is in every instance exterior to the different eminences from which they proceed, they all evidently appear to be continuous with that substance; 2d, Almost every one of them begin by several separate filaments from each other; at times these are found very numerous, as in the trigemini and in the par vagum. The preceding ones on the contrary arise, the one from a single filament, the other from two; 3dly, Excepting the auditory nerve, all from their very origin have a more striking consistence than the preceding; 4thly, They are very slightly attached to the corresponding cerebral portion, so much so, that they are always separated when the pia-mater is removed. Thus the greatest care is requisite not to tear from the brain any of those nerves in raising it from its bony receptacle. The adhesion is particularly slight in respect to the pathetics, the motores communes, and the fascial nerves. One would even be led to suppose, if the case was but slightly considered, that they were only contiguous.

The spinal marrow gives birth to thirty or thirty-one pairs of nerves under the name of cervical, eight in number dorsal, twelve in number lumbar, five sacral, five or six and further to the nerve which returns to the scull to pass out again under the appellation of spinal. The characteristics of these nerves at their origin, are as follows: 1st, Like the preceding ones they are continuous with the medullary substance; 2nd, They form two cords, the one anterior, the other posterior. These two draw their origin by several filaments placed one over the other, most generally isolated and always very distinct from each other; 3rdly, The attachment of these nerves at their origin is much stronger than that of the preceding ones, a circumstance which depends upon a cause we shall shortly point out; 4th, The consistence of the spinal nerves is also very palpable in their canal. In consequence of what we have just mentioned, it is evident that the nerves do not arise deep in the cerebral substance, at least apparently, but that they take their origin from the external surface of this membrane. Several physiologists, however, have admitted a more distant origin than that which inspection demonstrates. They believed that the nerves of one side sprung from the opposite one, and that a kind of decussation in each pair took place not only in the brain, but also in the spinal marrow. This opinion is grounded on a singular phenomenon, namely, that paralysis generally takes place on the side opposite to that in which the brain has been compressed, a phenomenon of which diseases frequently afford an instance, and rendered likewise striking by experiments, as Lorri has ascertained. On the contrary, it is said that convulsions take place on that side where the brain has received the injury. But this fact is infinitely more uncertain than that of paralysis, which is indisputable. I do not believe that our actual knowledge can enable us to state any thing in support of this last case, and the anatomical opinion above stated is evidently contradicted by the first glance.

I shall make one single observation in respect to this singular phenomenon; which is, that it relates particularly to the nerves of motion: those of sensation are hardly ever affected by it. In fact it is well known that in wounds of the head, after apoplexy, &c. one of the eyes, one ear, one side of the tongue, one nostril, are not deprived of sensation, in the same manner as the muscles on one side have lost the faculty of moving. We do not become suddenly paralytic on one side in respect to sensation, as is the case in hermiplegia in respect to motion. Experiments cannot clear up this point, since we cannot so easily discover the alterations of sensibility as those of motion. However, in compressing the brain of two dogs, and rendering them paralytic on one side, and then, shutting alternately one eye at a time, to see if they could distinguish objects, and presenting by turns ammonia or other spirituous emanations to each nostril, I have not observed in the first property an alteration corresponding to that of the second. In the sensitive organs of man a discordance is frequently observed. One ear is more perfect than the other, one eye perceives objects at a greater distance than its companion, &c.; from thence proceeds the imperfection of hearing, from thence also proceeds a kind of strabismus, &c.; but the cause of such discordances seem to rest in the organ itself, and to be perfectly independent of the brain.

Besides, it does not appear that each hemisphere always corresponds in a necessary manner with the nerves of motion on the opposite side. In fact effusions or injuries of the cerebral substance have often been noticed in the right side, without being attended with alterations in the motions of the left; and reciprocally—The following is the manner in which the cerebral membranes are disposed at the origin of the nerves; the dura mater forms a species of sheath in the foramen or fissure through which they pass, then quits them entirely, being partly lost in the cellular tissue, and in part reflected upon the borders of the opening to be continued with the periosteum. The optic nerve only affords an exception to this general rule; it is accompanied throughout its course with a fibrous sheath which extends to the sclerotic coat, which through its means communicates with the dura mater; 2dly, The arachnoid membrane surrounds each origin of nerves with a fold most generally in the shape of a funnel, whose widest orifice is towards the origin. In lifting up the brain with caution, or in removing delicately the dura mater from the spinal canal, this covering, which continues as far as the bony aperture through which the dura mater is admitted, is easy distinguished. It is then reflected on the surface of this membrane, corresponding to the brain, forming a kind of cul-de-sac between it and the nerve. Sometimes, as in the optic nerve or external motories, it penetrates the fibrous canal of the dura mater in accompanying the nerve, which it only quits at the middle of that canal, and which in consequence of reflexion, is thus partly clothed by the arachnoid membrane, and partly corresponding to cellular membrane; 3dly, The pia-mater is disposed in a manner more difficult to ascertain, and which has not yet been properly explained. I will speak of its mode of continuity upon the nerves in treating of the membrane proper to these.

Nerves run over a space more or less considerable before they pass out of the cranium or vertebral canal; 1st, The two proceeding from the brain display a greater extent inwardly than outwardly; 2dly, Amongst those of the tuber annulare, and of its dependencies, the pathetic only remain a considerable time in the scull before they pass out and have more of their length within than outwardly: all the others make their exit almost instantly; 3dly, The nerves of the spine run a greater distance in proportion as they are examined lower down. Above they become external almost immediately; lower down they are more than six inches in length within the canal, and consequently correspond with several foramina, before they reach their own: from whence it results, as Jadelot has observed, that if we make use of the spinal apophyses, on account of their protuberance, to judge of the origin of nerves, in the application of the moxa, we must, in order to operate in the neck, on a level with the origin of any nerve whatever, take the spinal apophysis exactly, which answers to the number corresponding to the pair we have in view; whilst, if we operate in the region of the loins, it should be applied much below that vertebra.

The direction of nerves to their origin is also very variable. In the brain and in the tuber annulare, it has no general rule; but in the series of the spinal nerves, that direction is almost perpendicular to the medulla at the top of the cervical region,—becomes gradually more and more oblique to the end of the lumbar region. These three things, the length in the canal, the thickness and oblique direction of the nerves of the spine, go on encreasing from top to the bottom, in a graduated manner, with some exceptions in respect to thickness.

Each pair of nerves, in proceeding from the brain, from the protuberance and its appendages, and from the spinal marrow, diverge into the two trunks of which they are formed; the olfactory only converge, and those of the spine ascend in a direction nearly parallel.

SECTION II.

Course of the Cerebral Nerves.

In proceeding from the bony cavities which enclose their origin, the nerves exhibit different dispositions.

Communication of the Cerebral Nerves at their Exit from their Bony Cavities.

1st. The two cerebral nerves proceed without communicating with any others, to their respective destination. 2dly. Those of the annulary protuberance, and of its appendages, begin to form communications, which are the more striking as they are observed in the inferior parts. That the par vagum and great hypoglossal nerves, in leaving their respective foramina, send forth numerous filaments to the neighbouring organs; whilst in the upper parts, the general motors, the pathetics, and even the trigemini, have this disposition in a much less degree; the auditory nerve does not communicate with any other. 3dly. The spinal nerves, are those whose communications at their exit, are the most striking, particularly in their anterior parts. The deep cervical plexus, the brachial lumbar, and sciatic, are the result of such communications, which the intercostals display in a less sensible manner.

These kind of plexus present a peculiar disposition. They are produced in the following manner:—In proceeding from the foramina, every nerve sends a branch upwards and downwards; then it receives some; so that the cords which succeed to those projecting from the foramina, proceed from two or three of these. These second cords, on dividing, send branches upwards and downwards, receive some themselves, and give birth to third cords; so that, in the brachial plexus, for instance, when nerves have ceased to communicate thus, and divide into isolated trunks, to proceed each to its destination, it is really impossible to say from what pair they proceed.

To ascertain with precision from what pairs the median, cubital, &c. proceed, would require a very tedious dissection.

It is this consideration which has induced me not to describe the spinal nerves in the usual manner; that is to say, proceeding from such and such pairs. I first describe in each region the plexus that the nerves perform in proceeding from the spine; thus, before the cervical nerves, I describe the deep cervical plexus; before the brachial nerves, the brachial plexus; before the lumbar and sacral, the plexus that bear the same name. The general disposition, the form, the connexion of these being ascertained, I proceed to the description of the nerves which go from them, either forwards, backwards, inwardly or outwardly, &c. without regarding the pairs which project from the foramina. This method has also appeared to me very convenient for pupils. For instance, nothing is more complicated than the description of the cervical nerves, in classifying them by the pairs from which they originally proceeded. But make yourself well acquainted with the deep-seated plexus proceeding from the anastomosis of these pairs, at their exit; then classify the nerves, 1st, Into internals, which proceed to the great sympathic; 2dly, Into externals, which are distributed upon the acromion and in the triangular space,—bounded on the anterior part, by the sterno mastoideus, and on the posterior part, by the trapesius; 3dly, Into anterior, which, being reflected upon the sterno mastoideus, form there, with the branches of the fascial, a kind of superficial plexus; 4thly, Into posterior, which proceed either to the occipital or to the posterior muscles of the neck; 5thly, Into those which pass downwards, as the diaphragmatic, those which communicate with the angular division of the hypoglossal, &c. &c. In this manner you will easily retain all the nervous distributions; because instead of having as many centres as there are pairs, you will have a single point to which the memory may refer the whole.

Interior communication of the Nervous Cords.

It is not only at their exit that the spinal nerves communicate in this manner. The different cords which constitute each, exhibit in every respect the same disposition, which is very easily ascertained in the large trunks, as in the median, the cubital, the radial, and particularly in the sciatic, &c.: on separating the different trunks of these nerves, we may perceive that they are not only in juxta-position with respect to their length, but that they frequently exchange ramifications with each other. These communications do not resemble those of the arteries, in which contiguity always exists between the branches that communicate. Here there is nothing but contiguity, and this is the way in which each of these cords, forming a nervous trunk, is, as we shall see, composed of filaments. It is then these filaments, which frequently straying from the cord to which they belong, proceed to the neighbouring one, so that after a pretty long course, the cords which begin the nerve are not composed of the same filaments as those by which it is terminated: in proceeding on, the whole is intermixed. Thus, the cords of the branches of the brachial plexus are not distributed in the same manner as those which terminate it; for there exists this difference between the plexus, which are very apparent, formed by the nerves themselves, and those which are less evident, formed during their course in their interior: that in respect to the first, it is the separation of the cords that form the net-work; whereas, in the second, it is formed by the filaments.

I once employed myself in tracing attentively, and to some extent, all the filaments of the sciatic nerve, and found that those which above composed the exterior cords, below were for the most part in those of the centre.

This remark proves that there are not some nerves for sensation and others for motion, and that if these nerves do not answer this double purpose, the difference is in the filaments and not in the cords.

In the interior of the vertebral canal, where the nervous cords, from the deficiency of cellular membrane are very much asunder—the filaments of which they are composed do not communicate with each other in this manner:—here, as without, there is no interior plexus of the nerve. This remark is particularly applicable to the extremity of the canal, where, as I have said, the nerves run to a considerable extent.

The communication of nerves on issuing from their bony cavities is so very general, that it may be said they form on each side a kind of organ continuous throughout; an organ, to the formation of which, the optic, the olfactory, and the auditory nerves only, do not contribute.

These kinds of communications, however, all of which are formed by juxta-position, seem to have no great influence on the functions of nerves. Each of their cords, although belonging in their course to several different trunks, can very well fulfil their functions in an insulated manner, which may also be said of every filament, although concurring in their process to form several cords of the same nerve.

I must observe in this respect, that it is requisite carefully to distinguish these communications from the anastomoses, in which two nervous threads, projecting from opposite parts, are intermixed and indentified with each other, which is observed in those of the face, of the sub orbitar, in those of the chin, &c.

Trunks of the Nerves.

After having thus communicated at their exit, the nerves separate from each other, and proceed to their respective organs. They form at first considerable trunks, which, in a course of greater or less extent, traverse the great cellular interstices. The form of these trunks is sometimes flattened, as in the sciatic, but more frequently it is rounded; although this form does not influence the nervous action, since nerves which are naturally round when flattened by a tumor fulfil their office as usual. In general, whenever it does not interfere with the object, nature makes choice of the rounded form for the organs of animals. I observe even in this respect, that these forms require a system generally diffused, and destined to fill up the spaces which must unavoidably result from the juxta-position of these circular organs. This system is the cellular. It would be much less necessary, if square surfaces were those our organs exhibit, because less space would be left between them.

Nervous trunks differ in length. Those of the limbs hold the first rank in this respect, because the extremities being more distant from the origin of the nerves, these trunks must consequently over-run a tolerable course before they distribute their filaments; on the contrary, in the chest and in the head, as the organs are immediately contiguous to the nerves intended to penetrate them, the division into branches is more immediate, and the trunks are very short.

The nervous trunks are sometimes accompanied with a corresponding arterial or veinous trunk, such as the brachial, the crural; on other occasions, as in the sciatics, those of the par vagum, &c. proceed alone.

Nervous Branches, Filaments, &c.

By degrees, as trunks proceed on, they scatter here and there different branches; these produce divisions, which in turn shoot forth filaments, from whence the last divisions arise. All these various divisions form very different angles. The acute angle is more generally met with. This is not a real origin, but merely a separation of several cords united for the branches, of one or two for the divisions, of one single cord for the filaments, and of isolated threads for the last division. Thus is this separation effected higher up or lower down, according to the subject. The part where it occurs is never strictly determined.

In consequence of these divisions, the filaments that compose the cords of each nerve, and even these very cords, differ in length; the shortest separate first, then the intermediate ones; in short, the longest of all continue the whole extent of the nerve, and terminate only with the same. The brachial and crural nerves present this distribution in a striking light.

The nervous branches are most generally accompanied with an artery or a vein, particularly in the extremities, for in the trunk there are some exceptions to this rule. In the neck, for instance, arteries will frequently form an angle with the nerve, instead of accompanying it in its course. In the head, several arterial branches are seen perfectly apart from those of the nerves. This circumstance is sufficient to make us attach less importance than some authors have required to this state of juxta-position, so frequent in the nervous and arterial systems; besides, if this juxta-position were so essential, it would appear in the smaller branches and filaments. But this is scarcely ever the case.

SECTION III.

Termination of the Nerves.

By this expression I imply the spot where each filament terminates, and not that only where the entire trunk ceases; so that the sciatic will terminate in the thigh, in the leg and foot, but not exclusively at the extremity of this last. In fact, in consequence of what I have already said, and of what I shall state hereafter, the re-union of the filaments into cords, and that of the cords into trunks, are nothing but a disposition which is unconnected with their functions, and every filament must be examined. From thence it follows, that the filaments of a nerve have three distinct terminations. They proceed; 1st, With other filaments of the same system; 2dly, With those of the system of ganglions, from thence result anastomosis; 3dly, They are lost in the organs.

Anastomosis with the same System.

I have already observed how essential it is to distinguish real anastomosis from the conjunction of a cord which passes to a nerve more or less distant from that to which it belongs, and which merely joins the filaments of the latter, to form together the nervous cords. Thus there is no anastomosis in the plexus, in the union between the cord of the tympanum and the lingual nerve, &c. In the same manner, although the filaments of the different cords of a nerve frequently proceed from the one to the other, so as to give the nerve the texture of a real plexus, and not as anatomists pretend, a mere thread-like texture, yet it cannot be said that the cords of the same nerve anastomose with each other: there is nothing but apposition. On the contrary, the communication of the great hypoglossal with the cervical pairs, from whence proceeds the nervous interspace, &c. forms a real anastomosis, because there is continuity, and not merely apposition of the nervous filaments.

If those that have considered anastomosis as the exclusive cause of all sympathies, had only reflected how very few there are, compared with what they seem to be at the first glance, they would have been led by this simple reflection to a different opinion. In fact, it is very evident that, although a filament unites with a trunk, it is no more connected with the filaments of that trunk than those are with each other; that is to say, that it has nothing in common with them more than the cellular covering. The anastomosis of arteries and veins are more frequent than those of the nerves. I believe that these may take an active part in neuralgies, even in some sympathies with which the mere contact of the filaments are not connected.

Anastomosis may generally be referred to three classes; 1st, Two branches proceeding from distinct nerves may continue together, as in the instance already mentioned of the great hypoglossal; again, as in the ramifications of the fascial with those of the sub orbitar of the occipital with the frontal, &c.; 2dly, Branches of the same nerve may unite in the same manner as the three portions of the trigemini; 3dly, Sometimes the two nerves of the same pair, or those of two different pairs, but proceeding from each hemisphere of the nervous system, may unite in the median line, as some instances of it are seen in the superficial nerves of the neck, in those of the chin, &c. This union does not take place in the abdomen, where the median line being entirely aponeurotic, contains no nervous branch in its texture. This anastomosis, which takes place in the median line, may perhaps explain why certain motions can still subsist in parts affected by paralysis. These kinds of anastomoses, however, are in general very rare. It is evident they cannot take place in the limbs; in the back of the trunk very few instances of it are ever perceived, and very few in the anterior part. If every pair of nerves produced them, it is evident that hemiplegia could hardly ever take place, since the sound part of the brain, or that of the spinal marrow, might influence through them the nerves of the afflicted side.

Anastomosis, with the System of Organic Life.

This termination bears a considerable analogy to the foregoing, since it proceeds from two nerves which unite at their extremities, and intermix in such a manner that it cannot be said where one begins or the other ends. I shall treat of these in the following system.

Termination in the Organs.

The exposition of the following systems will display the different kinds of terminations in respect to nerves. 1st. In some, many of these are met with, as in the mucous, in the dermoid, and in the muscular systems of organic and animal life. 2dly. In others a smaller number is observed, as in the cellular, the glandular, &c. 3dly. Some of them require a more minute examination than that which has hitherto been made, in respect to nerve, with which we are little acquainted, as the serous, the medullary, and a part of the fibrous, &c. Finally. Several, as the cartilaginous, the fibro-cartilaginous, those of the hair, the epidermis, the tendons of the fibres, &c. are evidently deprived of nerves.

We are still ignorant of the manner in which each filament terminates. Does it divest itself of the theca? Does the pulp only penetrate the interior of the fibres? In the optic nerve this last distribution is evident. The theca terminates on entering the eye, and the pulp expands, to form the retina. A similar expansion seems also to take place in the olfactory and auditory nerves; but in respect to the others, nothing has yet been ascertained.

ARTICLE II.

Organization of the Nervous System in Animal Life.

SECTION I.

The peculiar Texture of that Organization.

EVERY nerve is formed, as I have already stated, of a more or less considerable number of cords in apposition. These cords proceed from filaments similarly disposed, and united together in the same manner by a portion of the cellular membrane. I have already described how, in the interior of the nerve, they interweave with each other, so as to form within a kind of plexus, which differ only from the true plexus, in their branches being so closely applied to each other that their plaitings cannot be discovered at the first glance.

The general disposition of the nervous cords vary considerably. 1st. They are not everywhere of the same thickness. Those of the sciatic and crural nerves are looser than those of the brachial, excepting, however, the median. 2dly. Several nerves, as the par vagum, are formed by a single cord divided by numerous furrows. Sometimes it is inclosed by a net-work of filaments, attended all round with a kind of very delicate plexus. 3dly. The same nerve will sometimes conjoin cords of different sizes. In several, as in the sciatic, they are all equal. In the optic nerve, although of a tubular shape through its whole extent, from the commissure to the eye, does not appear to have that plaiting which the others exhibit so evidently. 4thly. In the posterior part of this nerve, and in the trunk of the olfactory, the cords are not distinct. 5thly. In most nerves the filaments, at their origin, are insulated. The trigemini, on the contrary, exhibit a common pulpous portion, in which its filaments seem to be implanted, &c.

From all these considerations, and from many others, for which we are particularly indebted to Reil, it follows, that the interior conformation of nerves varies in a particular manner; that almost every one of them present a different texture; that in this respect they bear no resemblance to the arteries nor to the veins, which are in every instance alike, whatever may be their volume, their course, &c. These varieties, however, do not affect their intimate structure. It is this structure which it concerns us to point out accurately in the last filaments that can be separated. Reil appears to me to have thrown a considerable light on this subject. I have repeated with exactitude his experiments, and have obtained results very analogous to his own: a few only have appeared to me so difficult, that I have not even attempted to undertake them. To his researches I have added a considerable number of new facts, which may be easily ascertained by comparing his work with this chapter, in which nothing will be found inserted but what is supported by strict observation. I have suppressed all the theoretical ideas which Reil had associated with his facts.

Two things are to be distinguished in every nervous filament. 1st. An external membrane of a tubular form, which contains the marrow. 2dly. The nervous marrow itself; each of which I shall treat of separately.

Of the Theca or Nevrileme,* *and its Origin.*

This membrane supplies every nervous filament with a real canal, which contains the marrow in its cavity in the same manner as veins or arteries contain the blood, except that the marrow is stationary, and the blood circulated.

The origin of the theca, or *nevrileme*, is very conspicuous in the spinal marrow; it is continued with the dense and thick membrane that enclothes its white substance, and which is called the pia-mater, although it does not bear the least resemblance to the membrane of the same name that incloses the cerebral circumvolutions. To see this origin distinctly, the spinal membrane should be divided in a longitudinal direction both in the front and in the posterior parts. The marrow then appears whitish, soft, and easily separable. If this be done either by scraping it with the scalpel, or with any other instrument, the immediate covering of the spinal marrow is obtained, perfectly distinct on either side, particularly if the caution of washing it has been attended to. It might even be procured in the shape of a bag, by cutting a portion of the marrow of a tolerable length, and afterwards by pressing the medullary substance through both ends. In this two-fold experiment, nerves will adhere to the membrane, divested of its medullary substance, because their sheath is continued with it. It is exactly the same case as if a mass of minute arteries were given off from the aorta: the parietes of this artery would be to the nerves what the pia-mater of the spinal marrow is to the theca of the nerves which proceed from it; with this distinction only, that nerves are white because they are filled with marrow, whilst the canal to which they are attached is transparent, because it is deprived of this matter. I do not, however, pretend to say that there exists a perfect identity between these two membranes, since we are ignorant of the precise nature of either; I merely point out the anatomical disposition.

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* *Nevrileme* is a word Bichat has formed from the Greek: he has introduced it in the science to express the system of the theca, and no author, I believe, has made use of it before him. As it is perfectly intelligible as French, and no other word could be substituted for it in English, except that of theca, I have let it remain, and employed them at pleasure for the same purpose.

In respect to the origin of nerves contained in the bony cavity of the scull, those proceeding from the tuber and its appendages, that is to say, the projections it receives from the brain or the cerebellum present a disposition analogous to that in the nerves of the spine. The difference, however, in the thickness and density of the pia-mater, establishes some distinctions. In fact the pia-mater which enclothes this part is different from that which constitutes the canal containing the spinal marrow; it is much softer, less adherent, is lacerated with much more facility, and appears analogous to that which envelopes the cortical substance of the brain. The theca of the nerves of the tuber, which is evidently continuous with that portion of the pia-mater, presents in some degree this character. At their point of union it is softer than in the canal; from whence proceeds the great facility with which, as I have observed, these nerves are torn away at their origin. The continuity with the pia-mater is further ascertained by the facility with which the nerves yield when this membrane is removed: generally speaking, they give way together.

In respect to the cervical nerves, the olfactory, enveloped by the pia-mater, but in a loose manner, seems deprived of this theca. In the optic nerve, from its origin to its conjunction with that of the opposite side, it is evidently wanting. At this point it begins to be invested by it. From this result canals filled with the medullary substance, and which extend to the retina. Besides this nerve differs essentially from others: 1st. Because it is enveloped by a kind of general *nevrileme;* 2dly. Because its medullary substance is more abundant, and more readily obtained, its canals being larger; 3dly. Because these being compressed together give it within the appearance of an uniform body; but by a longitudinal incision, it is easy to perceive that the medullary substance is separated by partitions. The auditory nerve is also distinguished by a peculiar texture.

From what we have said, it is evident that of the membranes of the brain, the pia-mater bears the most analogy with the *nevrileme.* It might almost be said, that in the vertebral canal they are one and the same; in fact, it may be noticed, that this membrane, which has not hitherto been properly described, presents, according to the manner it is examined, three essential modifications; 1st, In the cortical substance, which incloses the whole brain and the cerebellum, where it is of a reddish hue, excessively vascular, slack, capable of little resistance, and removed with facility; 2dly, In the white substance, which covers both anteriorly and posteriorly the tuber annulare, and the four main projections it receives from the brain and cerebellum, where it is of a lighter red, when it begins to acquire a little more firmness, becomes more adherent, and lacerates with much more difficulty; 3dly, In the whole extent of the spinal marrow, and even in the projections of the corpora olivaria and pyramidalia by which it commences. It thickens and is condensed on a level with the furrow that separates those projections from the protuberance, then increasing in density as it proceeds downwards, becomes whiter, firmer, &c. It presents an aspect perfectly different to that it bore in the scull. One might be induced to say that it is quite a different membrane. Its thickness is that of four to one, compared with the arachnoid.

In the greatest part of the subjects that I have examined, I have found it very much stretched, compressing in some measure the medullary substance, whose canal it forms; so that if a small puncture be made, this will instantly issue forth, but I believe that during life it is slacker. However, this state of compression, from the difference of thickness, is much less striking in the upper than in the middle or lower parts. I have remarked, that the density of the pia-mater in the spine is necessary for the protection of the medullary substance, which on one part is very soft, and on the other is less voluminous than the diameter of the canal; so that it may even be shaken within: a very different disposition to that of the brain, which exactly fills up every cavity of the cranium.

The theca of the nerves, produced in the manner we have mentioned, accompany these through the cavities of the cranium and of the spine. In these cavities it is very distinct, because it is not involved in cellular membrane, but merely in the arachnoid, which can be removed with the utmost facility; so that instead of making use of the divers preparations Reil has described, to separate the theca from the cellular texture of the nerves, it is much more convenient to examine this membrane in the last of the spinal nerves, which are there, as we have already noticed, of a considerable length.

Effects of certain Substances on the Theca, or Nevrileme: *its Resistance, &c.*

The theca external to the bony cavities, immersed in the cellular membrane, adheres to it in a very striking manner, but appears evidently to be of the same nature as that within. We are ignorant of its nature, whether or not it is identical with that of the pia-mater, of the medulla of the tuber annulare, and its appendages It appears to be strongly allied to the cellular membrane: it is transparent, and consequently of a different colour to that of the nerves. On this account, when these have been deprived of their pulp through the means of alkalies, they lose, in a great measure, their whiteness.

The theca, or *nevrileme*, is, in the animal economy, one of those parts that shrink with the utmost facility, particularly at the moment the nerves are dipped in a rather concentrated acid, as the nitric or sulphuric especially. I have not observed, in any other membrane, this phenomenon in such a striking degree; the nerve instantly lessens its volume and twists in divers directions. Now, we shall see, that the medullary substance does not exhibit this phenomenon. A similar effect is produced by the action of boiling water: through its means the nerve is drawn together, contracted and hardened. Afterwards, when ebullition has been continued for a certain time, it softens by degrees, and exchanges its whitish hue for a yellowish one, very distinct from that of a tendon or an aponeurosis that has undergone the same experiment. The action of acids continued for some time, produces an effect analogous to that of ebullition. To the sudden toughness and hardening which take place when a nerve has been dipt into these, succeeds such a degree of softness, that after some time it will flow between the fingers, and is afterwards partly dissolved.

Alkalies do not cause the theca, or any other membrane in living bodies, to contract; neither can they dissolve them. On this account, Reil, having macerated a portion of nerve for some time in soap-lees, has succeeded in separating the canal of the theca from the medullary substance.

The effect of water on the theca, exhibits a phenomenon presented by very few of the animal membranes. Far from softening, and from reducing it to a pulpous state, it seems at first to increase its consistence. A nerve becomes harder and firmer by steeping it in water, and in the ordinary temperature of cellars will continue in this state for six weeks, and even two months. It is only after this interval, and often some time after, that the tissue of the theca softens by degrees, separates, and is ultimately reduced, as all other membranes, to a pulpous state, by the process of maceration.

I have not repeated these experiments in a very warm temperature; in that of spring or winter they have always been attended with success.

The thecal canal of the nervous filaments opposes a very considerable resistance, because, in proportion to the medullary substance it contains, it is infinitely narrower than the membranous canal of the spinal marrow. In like manner, the proportion existing between the thickness in the coats of blood-vessels and the fluids they contain, is very considerably less in the large trunks than in the small ramifications: in the first the quantity of the fluid exceeds that of the solid substance; they are at least equal in the second. A very diminutive nerve will support a greater weight than the spinal marrow. I believe that amongst the textures that are disposed in filaments or in extended tubes, this and the arterial, after the fibrous, present the greatest resistance: they surpass the veinous, the muscular, the serous, &c.

The Medullary Substance: its Origin.

This substance occupies the interior of the theca, or *nevrileme,* in the same manner as the substance of the spinal marrow fills the canal that is formed for it by the pia-mater. This medullary substance is of a whitish hue, as that of the brain and of the spinal marrow; it is from this that nerves borrow their colour. In the optic nerve it exists in a greater degree than in all the rest. It is exclusively met with in that part of the nerve which is posterior to its union with its fellow, which is also the case in the olfactory. In the auditory nerve, which appears to be principally formed by it, it is also found very abundant. In general, I believe, that at the origin, in the bony cavities, it is in greater quantity than the theca, whilst in the course of the nerve it is quite the reverse. From this proceeds the great resistance which nerves, considered in the second instance, display, when compared with the same in the first.

This substance seems to be continuous with the medulla of the brain, of the tuber and its appendages, and of the spinal marrow. I should think it would be impossible to deny this kind of continuity in the origin of the optic and olfactory nerves, in which this substance only is displayed; in the auditory this is also very apparent; in the spinal marrow, by scraping the white substance at the internal surface of the pia-mater, so as to leave the nerves adhering to this membrane, it is evidently perceived at the point where these nerves project, that there is an extension which sinks into their theca.

Comparison of the Medullary Substances of the Brain and Nerves.

What is the nature of the medullary substance in nerves? I have attempted tc draw a line of comparison between this and the cerebral substance. In some respects there is a considerable analogy: where is the difference in others? 1st. The white substance of the brain, when dried in the open air, and in thin slices, to avoid putrefaction, becomes yellow, and acquires a certain consistence. The dried nerve also becomes yellow, inflexible, and contracts upon itself. The changes in this case are without doubt in part owing to the theca and its system. The proof of this is, that if the envelopement with which the pia-mater supplies the spinal marrow, an envelopement that has so much analogy with the *nevrileme,* the additional qualities it receives are very analogous to those of the nerves which have undergone the same process. But it does not follow from this, that the medullary substance of the nerve may not concur, through the means of the evaporation of its watery substance, in producing the yellowish hue. I will adduce a general remark relating to this, and which appears to me interesting. It is, that water performs an essential office in respect to the whitish appearance of numberless membranes, which assume a yellowish or greyish hue when this fluid is withdrawn, and again resume their natural colour by its addition. Thus, by means of dessication we can render yellow all the fibrous organs, the skin, &c. and restore them again to their primitive colour. Thus, serous surfaces, the cellular membrane, &c. after having undergone the process of dessication, will, when dipt in water, re-assume their usual appearance, except where they have been dried a very long time. The epidermis of the sole of the foot or of the palm of the hand, when it has been immersed for some time in water, exchanges its natural grey for a white colour.

2dly. The cerebral substance, and that of the spinal marrow, putrefy with the utmost facility; when they are submitted to the united effects of water and atmospheric air, they become of a greenish hue, acquire a degree of acidity, and redden blue paper. Of all animal substances, this phenomena takes place the soonest in these. On the contrary, the nervous substance seems to resist putrefaction for a much longer time. The nerves are even amongst those parts in the animal economy that are the least disposed to putrefy. During life, they are frequently seen perfectly sound in a mortified limb, or in the very centre of an abscess, &c. In the dead body undergoing putrefaction, they still preserve their whiteness and their consistence, although surrounded on every part with putrefied substances, and in the very midst of general dissolution. I have observed that the water made use of in macerating nerves hardly exhales any smell; whilst that employed for the brain becomes fœtid and offensive. These phenomena would evidently not take place if the medullary substance of the nerve yielded to putrefaction as easily as that of the brain. However, it is evident that it is specially to the theca or *nevrileme* that the nerves are indebted for this kind of incorruptibility; for I have observed that the optic nerve, in which the cellular substance predominates, that the olfactory and the auditory nerves, that seem deprived of it, undergo dissolution more speedily than others. I have also constantly observed, that whilst the white substance of the spinal marrow is corrupting, its sheath remains unchanged.

3dly. The medullary substance of the nerves, like that of the brain and of the spinal marrow, do not appear susceptible of being hardened in any way. This is made very striking when the two last are dipped in boiling water, or in a concentrated acid, &c. In respect to the first, it is ascertained in submitting to the same experiment the soft nerves, in which the theca is hardly distinct. To this also must be attributed the following phenomenon:—when the anterior part of the optic is immersed in boiling water, the theca shrinks, its canal contracts, and the medullary substance not shrinking in proportion, flows towards the extremities, which become swelled. As this substance in the other nerves is in a smaller proportion, this phenomenon is less striking; however, it does take place; and to this cause must be attributed the same round tubercles which the terminations of nervous filaments present when boiled. It is the medullary substance that forms these swellings. This phenomenon is very remarkable in the spinal marrow, which being immersed in boiling water, suffers its compressed substance to escape through its extremities, or the apertures that are made in any part of its covering. Thus, when the head is boiled, the dura-mater separated from the cranium is strongly contracted, or becomes harder, compresses the cerebral substance, which not being contracted in a similar manner, ruptures the former, so as to become diffused within the space formed between the skull and dura-mater, in the process of boiling.

4thly. When the cerebral substance is agitated in water, at first it floats, as Fourcroy has stated, in the form of an emulsion, then precipitates to the bottom of the vessel. A similar emulsion may be obtained from the olfactory, from the posterior parts of the optic nerves, &c. When the anterior parts of these, in which the theca is very distinct, has, for some length of time, been soaked in water, and even commonly without this preliminary caution, a large quantity of a whitish substance, and which is evidently analogous to the medulla of the brain, and which colours the water in which it is received, may be forced out by pressure. In the other nerves, where the medullary substance is much less abundant, it can also be often expelled by pressure through the extremities of the divided filaments, particularly if they have previously been macerated in alkaline lees.

5thly. Boiling hardens the brain, and gives it the greyish and tarnished hue similar to that which is observed in phrenites fevers. The like phenomenon exists in the soft nerves; in the others the theca, which enclothes the medullary substance, is in too large a proportion to ascertain what takes place. It is to the property the brain possesses of coagulating, by means of caloric, that we must attribute the flocculent precipitate obtained in an emulsion of brain, when submitted to heat.

6thly. All kinds of acids, if they are strongly concentrated, harden the brain in a very sensible degree, at the very moment of immersion; the sulphuric then softens it, and if not weakened, would reduce it in a pulpous state. The nitric will only, in hardening it, tinge it of a yellowish hue: it is less affected by the muriatic. The phenomena produced by acids in these nerves are tolerably analogous in the soft ones. In those provided with a very distinct theca, the process of hardening, of which it is the seat, conceals every phenomena that occurs in the medullary substance. When the theca becomes softer and fuses, this substance has appeared to me to diminish in consistence, and to be changed by acids, whilst that of the brain still preserves the same degree of hardness, provided the concentration has not been carried too far.

Every one is acquainted with the effects of alcohol upon the brain, which it also hardens. This hardening the result of acids, of boiling of alcohol, is a phenomenon of which the anatomist can avail himself, by giving to the parts that he dissects a degree of consistency that will enable him to examine them accurately. He makes the cerebral substance approach to albuminous fluids. I say approach, because very essential differences still exist between them, with which I conceive we are rather imperfectly acquainted. The action of alkalies is quite different to that of acids on the cerebral substance. They reduce it to a fluid state, and even, in the course of time, dissolve it completely. I have even noticed in this respect, that the grey substance yields sooner to their effects than the white, which softens considerably, and partly disappears, but always leaves a considerable portion undissolved. From whatever part these substances are taken, in order to try the experiment, the result is the same. Alkalies, also, act powerfully on the medullary substance of nerves, which, as I have already mentioned, has been of great service to Reil, in prosecuting his experiments.

8thly. Thouret and Fourcroy have made us familiar with the singular property that brains which have been buried, possess of changing, (after being condensed into a smaller volume than that they exhibited before,) into a brittle substance, which softens between the fingers, can be diluted in water, exhales an insipid smell, presenting the characteristics of ammoniacal soap, and resembling very much the spermatic matter of the whale. Do nerves experience a similar change in their medullary substance? It has not as yet been ascertained.

9th. The muriate of soda, with which we sprinkle slices of the brain and the pulpous nerves, adds to their consistence.

10th. The gastric fluids in general act rather powerfully on the medullary substance of the brain. However, I believe that their action is more effectual when this is in the raw state, than when it has been boiled, because in general all dissolvents act more effectually on that substance in the first of these cases. We know, that with the greatest part of carnivorous animals, the brain is a delicate morsel. Those that feed upon birds in which the skull is easily divided, devour the brain in the first instance. The weasel and polecat afford examples of this. Even for the human species, the brain is also one of the daintiest and most savoury portions in the body. Nerves are much more difficult of digestion; but this proceeds entirely from the theca, which does not, as many other parts, so easily give way in the process of boiling. For instance:—the tendons, which in their crude state are harder than the nerves, become much softer by boiling, so that in boiled meats these organs are easily distinguished from each other; the first in its gelatinous state, is much more palatable and easier of digestion.

11th. The medullary substance of the brain is very different in the brain itself, in the tuber, its prolongations, and in the spinal marrow. However slightly these are examined, we are struck with the differences that relate to the colour, the consistence, the firmness, the moisture, and without doubt, to the colour, although our knowledge is not sufficient to enable us to decide upon this point. Does the medullary substance of the nerves afford analogous distinctions? I believe that in the different nerves it varies according to their function. In fact, since the interior dispositions of the cords and filaments which constitute the nerves vary so essentially, since the thecæ are also liable to differences, why should the medullary substance be in every instance the same? Undoubtedly, the colour and consistence of that which forms the olfactory nerves, are very different from what is forced out by pressure from the anterior part of the optic nerve.

In the auditory nerve it differs from that of the trigemini, &c. We have seen that each organ of sense is endowed with a peculiar sensibility that places it exclusively in relation with peculiar bodies in nature; that of the eye with light, that of the ear with sounds, &c. I certainly admit that these distinctions of sensibility proceed from the differences of the organs. But I am convinced that the organisation of the nerves has a considerable influence, and that the optic would be but indifferently calculated to transmit savours, the auditory to propagate the impressions of light, &c. However slightly they are examined, we perceive an essential difference of structure between the nerve of the eye, that of the nostrils, of the ear, and that calculated for taste in the tongue, which, on account of its density, bears some analogy with the motores. In respect to the nerves that preside over the sense of feeling, they have no occasion for a peculiar texture, because I shall prove hereafter that this sense does not require a peculiar mode of animal sensibility, but that this general property suffices, since it is from the mechanical shape of the hand that its precision particularly depends. With regard to the nerves that pròceed to the voluntary muscles, as these are every where analogous, and fulfil similar functions ; I believe there exists no distinction in their medullary substances. But in the par vagum, whose destination is so dissimilar, why should not the varieties of internal organisation coincide with those of the texture so remarkable on dissecting this nerve ? I might say as much in respect to several nerves which proceed to such parts whose sensibility is quite differently modified. Here then is a parallel between the cerebral pulp and the medullary substance of the nerves, and which may throw some light on their differences and their analogies. I have not gone through all the particulars of the chemical experiments hitherto made upon the brain. I have merely pointed out the phenomena of the effects that divers re-actives will create, phenomena that I have repeatedly verified myself.

The medullary substance in the nerves is not distributed into filaments. It seems analogous to the white substance of the spinal marrow, which is a real pulp, stationary in the canal of the pia-mater, that serves to contain it. Besides, in the optic, auditory and olfactory nerves, this assertion is proved by inspection. In general I think that this substance, as well as the cerebral, excepting the nerves that pervade them, ought rather to be classified among the fluids than amongst solids; or it may be considered to hold a medium state between the two.

SECTION II.

Parts common to the Organization of the Nervous System in Animal Life.

Cellular Membrane.

The nerves are completely deprived of their membrane in the interior of the cranium and of the spine, but outwardly they are plentifully supplied with it. They are in the first place covered by a large external layer, that connects them with the neighbouring parts. This is of a slacker texture than that which encloses the arteries; adipose matter very frequently accumulates within. In dropsies it is sometimes, though rarely, infiltrated with serum.

From this common layer different projections pass outwardly, and communicate with the cellular membrane of the neighbouring organs. Other projections also take place, and are continued between the nervous cords, which they separate from each other, and supply with a kind of ducts or sheaths. When a nerve has been macerated for any space of time in diluted nitric acid, the cords separate from their sheaths, which is in respect to them individually what the layer we have just mentioned is to the whole nerve. Thick nerves frequently contain fat in their cellular canals; in the sciatic it is always to be found. This explains why, on drying these organs, there is almost always, as I have observed, an oily exudation from their surfaces. Why, when dipt in any alkaline lee, they become unctuous, and more evidently of a soapy nature?

Finally, new ramifications projecting from the cellular canals which enclose the cords, also surround the filaments with sheaths of a still smaller description. Here fat and serum are never produced, and the cellular membrane partly borrows that peculiar nature which characterises the sub-arterial, the sub-veinous tissues, &c. The theca or *nevrileme* is perhaps nothing more than this tissue rather more condensed: however, the cellular membrane unites so closely both of these, the cords of the nerves, and the filaments of the cords, that no motion whatsoever can take place.

Blood Vessels.

Every nerve receives its blood vessels from the neighbouring trunks, whose ramifications penetrate them internally in every direction. The optic nerve is an exception to this rule. The membrane that encloses it, is so disposed as to prevent the surrounding vessels from entering laterally. An artery passes through in the direction of the axis, and supplies it with several branches.

In the other nerves, the arteries wind at first in the cellular tissue, between the cords, and are of greater or less size, according to the nervous trunks. This size is sometimes considerably increased. For instance. In popliteal aneurism, the artery of the sciatic nerve is frequently seen with a calibre more than three times larger than in its natural state.

From the arteries twisting between the cords, project numerous small branches, which resort to the spaces left between the filaments. Finally, from these proceed small capillary arteries, which spread on the theca, winding and crossing it, and continuing with the exhalants of the medullary substance. This vascular distribution is very distinct on the spinal marrow. Numerous ramifications at first spread on the pia-mater dense and tight, and performing the office of the theca; but they are immersed in the medullary substance, and are lost therein in connection with the exhalants.

Veins in respect to nerves follow a course analogous to that of the arteries; however, in dissecting carefully several large nervous trunks, I have ascertained that, most generally at least, their branches do not pass from the nerves in the same part where the arteries are admitted. This disposition is analogous to that of the brain, in which these penetrate in the inferior part, and the others proceed from above.

Several authors, particularly Reil, have exaggerated the quantity of blood that reaches the nerves, because, to judge of it, they have employed fine injections, that have penetrated into the capillary system, where, in general, no red blood is contained. I have been convinced how deceitful are these means, both in this case as in others; dissecting the nerves in living animals is the only method of forming a correct idea of what takes place in the natural state.

The blood that penetrates the nerves is like that which reaches the brain, a stimulant that sustains their action. When this stimulant is augmented, the nervous excitability is also increased, as Reil has ascertained, by rubbing the nerves of a frog so as to give them a reddish hue, from the increased quantity of blood which is directed to them. If that fluid be conveyed in some considerable quantity to the nervous system, it interrupts its functions, which happens in the brain, in cases of sanguinous apoplexies. Amongst the great number of bodies that I have opened, I have not as yet had an opportunity of ascertaining this fact in a very positive manner.

The nerves, in some cases, prove a little redder than in others. Do such cases coincide with certain established diseases? I have hitherto ascertained nothing in this respect. As to the pretended compression of the origin of the nerves by the blood which resorts to the brain or the spinal marrow, whoever has examined the connections between nerves and blood-vessels, in the basis of the cranium, will undoubtedly not admit of such compressions. Besides the greater part of the foramina, through which the small arteries penetrate in the very interior of the viscera, have a larger calibre, so that however full they may be, they cannot be pressed against their sides. We cannot conceive a compression at the origin of the nerves, but from effusions at the basis of the cranium.

Exhalants and Absorbents.

These vessels baffle inspection in nerves; but nutrition bespeaks their existence. It would seem that this function is performed in the following manner: the exhalants receive from the arteries with which they are continuous the medullary substance they deposit in the canal of the *nevrileme*, which is, if I may thus express myself, a reservatory for this substance, and which substance is afterwards taken up by the absorbents.

Several have thought that the theca is the secreting organ of this medullary substance, which filtrates, in some measure, through its parietes, to become afterwards stationary in its cavity. This I cannot admit of; 1st. Because in this case, neither the olfactory nerve, nor the posterior part of the optic, could be nourished. 2dly. The cerebral membranes have nothing to do with the secretion of the pulp of the brain; they only transmit such vessels as are intended to deposit its substance. 3dly. The same disposition is observed in respect to the spinal marrow, the pia-mater of which bears so much analogy to the theca. The vessels traverse this membrane, and are then lost, as I have already mentioned, in the medullary substance, which they constantly renew; so that if it were possible to remove this substance without injuring the vessels, their extremities would be found floating in the canal of the pia-mater. Thus, in certain fungouses of a very soft nature, the vessels are observed to cross in every direction the very substance they deposit in the interstices, and would form a kind of net-work, if we could strip them of this substance. 4thly. In the optic nerve, the vessels are evidently not confined to the theca; they penetrate besides into the canals it forms, and are lost in the medullary substance.

Every thing, then, concurs to prove that the theca is no more the secretory organ of the nervous substance than the pia-mater is of the cerebral substance, or that of the spinal marrow: It may be intended to perform offices we are not acquainted with; but undoubtedly its principal one is to serve as a sheath: it forms the passive part of a nerve, the marrow being essentially the active one. From this method of regarding the production of the nervous medullary substance, it is evident that it does not proceed from the brain, and that it is formed in every nerve by means of the neighbouring vessels. This explains why the inferior part of a divided nerve never withers; why a ligature, in intercepting the communications with the brain, does not destroy nutrition in nerves; why, in the greater part of palsies, where the nervous system has ceased to correspond with that organ, it is still as usual supplied with nourishment.

From this, and from several other considerations, Reil has regarded the nerves as enjoying an existence completely insulated, as separated bodies, communicating only, on one part, with the brain, on the other with the various organs. This assertion is correct, in respect to nutrition: as it relates to the functions it is partly erroneous, for most assuredly nerves are nothing but conductors; it is from the brain that motions emanate, and to which sensations are conveyed. In white-blooded animals, and even in those in which the blood is red and cold, these functions centered in man, and the approaching species in the brain are more generally, it is true, placed in the nervous system: from this undoubtedly it follows, that in reptiles, &c. the brain, the heart, and the lungs, may be extirpated without death being immediately produced. It is even on this account I have stated in my "Researches upon Death," that in such experiments we should never make use of animals possessed of cold blood, to form deductions in respect to those in which it is red and warm. But in these, and particularly in man, it is indisputable; 1st. That the brain is the centre of animal life, which ceases when the office of that viscus is destroyed, as in apoplectic strokes, asphyxias, &c. prove. 2dly. That organic life is connected with it, although in an indirect manner, that is to say, in presiding over the mechanical functions of respiration, which, having ceased, puts a stop to the chemical ones; then circulation, secretions, &c., so that the continuance of the two lives, and a serious injury of the brain, are incompatible. Those authors who have written upon life, upon the nervous system, &c., have, for the most part, viewed them too generally. The connections of functions are perfectly distinct in animals that have cold blood, and in those in which it is warm; what is correct in one case, is completely erroneous in the other.

Nerves.

Does the theca receive small nervous branches? Do these small branches penetrate the nerves in the same manner as the minute arteries ramify in the parietes of the large arteries? Anatomical inspection proves nothing of the kind.

ARTICLE III.

Properties of the Nervous System in Animal Life.

SECTION I.

Properties of the Tissue.

Few systems are possessed of this property in a less degree than this. If a nerve in a living animal be drawn in opposite directions, it stretches with difficulty, affords considerable resistance, and is rendered, in a trifling degree only, longer than in its natural state. This appears to proceed especially from the theca; the medullary substance would yield with much more facility. We know how great an extension that of the brain admits of in dropsies of the ventricles. If a large trunk be stretched by a subjacent tumour, as in popliteal aneurism, swellings in the axilla, &c. it is compressed in the shape of a ribbon; its filaments separate, and lay by the side of each other. Thus distended, these filaments can sometimes convey sensations and motions; on other occasions these two functions are completely annihilated.

In general they are more effectually checked by a sudden distension than by that which is brought on gradually. For this reason, the head of the humerus, in luxations of the arm, frequently produces palsies; whilst in large chronic tumours of the arm-pit, this seldom happens. The spontaneous luxations of the vertebræ, which generally follow a chronic course, are seldom attended with paralysis,—an accident which is always the result of those luxations occasioned by mechanical violence. Thus it is that in the brain osseous tumours and large fungouses, that increase slowly, but very slightly disturb its functions, whilst the least depression in any part of the scull, when it is the result of a fracture, completely subverts them. For the same reason, in hydrocephalus, a large collection of serum will hardly ever injure sensibility; whilst again, if a small proportion more than usual of this fluid be suddenly exhaled in the ventricles, it will nearly annihilate it, as is the case in certain apoplexies.

When some considerable region, as the abdomen, has been distended, the nerves in these parts yield partly, because their flexibility has disappeared, and partly because they are really lengthened; besides, more space is left between them.

The contractility of the tissues is still less striking than its extensibility. A nerve, if divided transversely, hardly contracts at its two extremities, which remain close to each other, like those of a tendon. In cases of amputation, the end of the nerve remains longer than those of the muscles of the skin, &c. This is even sometimes the cause of a very painful sensation, occasioned by the pressure of the dressings.

SECTION II.

Vital Properties.

THESE are less striking in the nerves than a superficial glance would at first induce us to believe, according to the opinion of several medical men, who have supposed these organs act almost a general part in diseases.

Properties of the Animal Life.

In respect to sensibility, nerves ought to be considered under two different lights: 1st. That which is inherent in them ought to be studied. 2dly. It is indispensable to ascertain what part they act in that of all the other organs.

Animal Sensibility inherent in Nerves.

This property is above all that which is the most strongly characterized in nerves. Laid bare and excited, they cause insufferable pains. On tying a nervous filament, in cauterising, or exciting it in any manner whatsoever, this consequence, so well known in chirurgical practice, by those who make experiments on living animals, is the constant result.

This property would at first appear to establish a very essential distinction between the medullary substance of nerves, and that of the brain, particularly with respect to the convex part of that organ; for this, when divested of the cortical substance, may be irritated almost with impunity; it is only lower down that animal sensibility becomes strongly characterized; and even then it is not so acute as in the nerves. It should, however, be noticed, that in experiments on the cerebral pulp, we destroy the very organ that perceives; that, without which there can be no animal sensibility, consequently that, whose derangement must unavoidably influence this property, whereas the seat of perception remains unmolested; where we irritate the nerve, the pain is very acute. It is in fact chiefly in the medullary substance of each nervous filament, that animal sensibility resides. In the theca, it is much less apparent. Hence the reason why the mere contact without compression, is hardly attended with pain; why a nerve may almost with impunity remain immerged in a purulent or ichorous fluid, in the sanious matter even of a cancer; why contact of air is scarcely felt when the nerves are merely laid bare, as I have had numberless opportunities to ascertain on animals; why, in numberless cases different tumours in the vicinity of which nerves are situate, have little influence over them. The membrane of each filament is in reality in all these instances a kind of shelter protecting their medullary substance, which is eminently the seat of sensibility.

In respect to the cellular texture, which concurs to the formation of nerves, it is, as in every other case, a stranger to this property. Why can we, as I have frequently done on living animals, separate with the point of a very fine scalpel, the different filaments of a large nerve; the sciatic, for instance, when they have been previously laid bare, without the animal experiencing much pain. In these experiments it is easy to be convinced of the deficiency of sensibility in the sheath of every nervous filament. It must be cut across, and the medullary substance must be injured to produce pain.

In experiments, the animal sensibility of the nerve seems by degrees to be exhausted, and finally to cease. I have ascertained it in the eighth pair, in my experiments upon injections of black blood in the brain. At the moment the nerve is elevated and drawn to separate it from the carotid to which it is attached, the animal cries out, and is greatly agitated; but when this has been repeated once or twice, he ceases to give signs of pain. If the nerve be not excited for an hour or two, sensibility is restored with a degree of energy when it is drawn again. These experiments produce a result analogous to those made on animal contractility in the muscles, and with which every physiologist is familiar.

The animal sensibility of nerves has a peculiar character which distinguishes it from that of every other system. It is this very character which has impressed a distinctive one in respect to pain proceeding from the organs, which in no way resembles that seated in the skin, and in the mucous surfaces, &c. What has particularly drawn my attention, in respect to the diversities of the pain of which each system is the seat, is the questions put by a man of very good parts and great presence of mind, whose thigh had been amputated by Desault, and who asked me, after the limb had been removed, why the painful sensation he experienced after the incision of the skin, was so different from that he felt when the fleshy parts were divided, in which the nerves, distributed in every direction, were affected by the knife; and why this sensation, again, differed from that which took place when the section of the marrow was performed. These questions puzzled me a great deal, being at that time engaged in surgery, and having applied myself little to physiology; but I have since been made sensible, that this depends upon the general principle I have already mentioned, and which proves, that in the same manner as every system, in regard to pain, has its peculiar mode of animal sensibility in the state of health, this mode also exists in that of disease.

A very convincing proof of this assertion, in respect to the nerves of animal life, is the peculiar mode of pain which is felt in the tic douloureux, which is perfectly distinct from that of any other system. The sciatic pain, which exists in the nerve of that name, has frequently been mistaken for that of rheumatism that afflicts the muscles or the tendinous parts; but the difference of the pain would alone enable us to distinguish them. Chaussier has very judiciously admitted, as the first characteristic in nevralgies, the very nature of the pain experienced. Every one is well acquainted with that peculiar sensation of numbness, followed by a pricking, which is experienced when a superficial nerve, such as the cubital, the peroneal, &c. have been compressed. In no other organ of the body is a similar sensation produced by this cause.

The animal sensibility of nerves has another peculiar characteristic; for instance, the local irritation of a nervous trunk often produces pain throughout all its branches: 1st, We are aware, that when the cubital nerve is compressed at the elbow, pain is felt throughout its course; that it is extended all along the external part of the leg when the peroneal suffers; 2dly, In *tic douloureux* of the face, in sciatic pains, and generally in the whole class of affections that Chaussier has arranged under the appellation of nevralgies, we make a similar observation; 3dly, When without dividing it, one of the branches of the saphena of the internal cutaneous, or of the musculo cutaneous, nerve is wounded in the operation of bleeding, the whole subjacent part is benumbed, and becomes painful and tumefied; the irritated point is the centre from which fatal irradiations are conveyed throughout the whole course of the nerve, the consequences of which can frequently be prevented only by dividing totally the injured trunk. Thus, in *tic douloureux*, the section of the nerves has frequently arrested the symptoms, although the operation succeeds less in cases where the disease exists through the whole of the nerve than in the other in which it is local; 4thly, I have irritated in a dog the sciatic nerve, by means of nitric acid. Next day the whole limb was swelled and painful. At this moment I have another in which the fore limb is swelled, because two days ago I had run a pin through one of the anterior nerves, taking care to penetrate the medullary filaments in the experiment. This precaution is essential; for having transfixed the cellular membrane which separates the filaments of the sciatic nerve, I obtained no result; however, I must confess, that these experiments are not always attended with success, and that on irritating a nerve in any part whatever, I have sometimes not been able to produce any particular occurrence; 5thly, The tying of nerves has scarcely ever been attended with bad consequences, because the communication to the brain is intercepted by the cause that produces the irritation, and also because the medullary substance is compressed, and its sensibility extinguished. Accidents, however, have frequently occurred from tying the nerve, in the operation for aneurism; and although there is no real danger in this method of using the ligature, yet all the best practitioners recommend it to be avoided.

These different considerations establish, in a positive manner, the influence that an irritated part of a nerve may have on the animal sensibility of all the subjacent ramifications. Physicians do not sufficiently attend to this cause of painful sensations, which are sometimes felt to a very considerable extent, without any apparent injury. A nerve irritated in a case of fracture of the ribs, in that of a limb, in a wound, tumor, &c. may produce in a very distant part a host of phenomena, the causes of which frequently escape us, although the case might easily be discovered, were we only to reflect upon the distribution of the branches proceeding from the trunk that may have been injured.

Why is it, that in these phenomena the animal sensibility of the nerve is always increased below the affected part? Why does not this phenomenon take place in that part towards the brain, although it is in this direction that sensation is conveyed in the state of health? This I cannot account for.

No other system amongst those in which all the parts, as in that of the nerves, are conjoined, presents the same phenomenon. The arterial, the veinous, the absorbent, systems are never similarly influenced in their different ramifications, by the affections of any part whatever of their trunk. The cellular system is never found affected in a part remote from the diseased one. In the mucous system, which is continuous, the irritation of one part may be communicated to another, as when a stone in the bladder occasions pain in the extremity of the glands; but then, there is always an intermediate part more or less extensive, which is not painful: it is a real sympathy; whilst in this case, from the affected part to the very extremities, all suffers in the nervous trunk.

Influence of the Nerves on the Animal Sensibility of all the Organs.

After having considered animal sensibility in the nervous system itself, we must examine what part that system acts with this property, considered in respect to every other organ, in which it is frequently the agent of transmission between the organ that receives the impression of sensation and the brain which perceives that impression; whenever, as in the preceding cases, any particular point of the nervous system suffers, the portion that lays between the injury and the brain, still serves to convey impressions. Thus in animal contractility, nerves are always the intermediate agents between the brain, which is the principle of motion, and the muscle which performs it. The first mode of transmission is, however, attended with more difficulties than this, which, to be properly explained, requires that two kinds of sensations perceived by the interior sensitive principle, should be distinguished: 1st, The external; 2dly, The internal.

The external sensations are of two orders: 1st, Those which are general; 2dly, Those which are particular. General sensations, as we perceive, proceed from the touch; they bespeak the presence of bodies that are in contact with the external organs; they convey the general impressions of heat and cold, of moisture and dryness, softness, hardness, &c.; they produce a painful sensation when the exterior organs are torn, pricked, irritated by a chemical agent, &c. These sensations may arise in the skin, the eye, the ear, the mouth, in the nostrils, and the beginning of all mucous surfaces, &c. Every shape in nature is capable of producing these, as all the exterior organs are calculated to perceive them; 2dly, The particular sensations relate to certain exterior and determined bodies, or to particular emanations from surrounding bodies. Thus the eye is exclusively calculated to perceive light; the nose, odours; the ear, sounds; the tongue, savours, &c. These peculiar sensations are in a certain degree independent of the general ones: thus the eye may cease to discern objects; the nose to smell; the ear to hear; the tongue to taste; and yet these different organs may retain the faculty of perceiving heat and cold, dampness, dryness, &c. and may become the seats of real pain. Have we not every day people afflicted with amaurosis, suffering from pain in the eye. Those labouring under deafness, suffering from ear-ache, &c. I have seen a man deprived of smell after the use of mercury, and yet the irritation of the pituitary membrane was very painful in this subject, &c. It is then very essential to distinguish accurately in the organs of our senses, what belongs to the general sensibility from that which depends upon the peculiar mode of sensibility each organ is possessed of.

If we now examine the parts the cerebral nerves perform in these two kinds of animal sensibility, it would appear that they are equally essential to each other: 1st; This, in respect to the organs of the senses, cannot be doubted. Sight, hearing, smell, or taste, have never continued to subsist after the optic, the auditory, the olfactory and gustatory nerves, have been materially injured. I do not allude to the touch, which does not require, as the other senses, a peculiar modification of animal sensibility, nor more than the general fact, but merely a peculiar form in the organs calculated for it, in order to adapt themselves to the conformation of exterior bodies; 2dly, In respect to general sensations, every time that the cutaneous nerves in any part of the skin cease to be totally active, they become perfectly insensible; it may be pinched, irritated, burnt, &c. without perceiving it. A complete state of paralysis in respect to feeling, exhibits in the human species this phenomenon, which may be artificially produced in animals, by dividing or tying every nerve that resorts to a limb. When the pituitary membrane, after having lost its peculiar faculty, is still sensible to the touch, the olfactory nerve only is paralyzed. If those nerves that enter through the spheno-palatine foramen, by the anterior and posterior nostrils, were to lose their action, the general feeling of touch would also be lost. It is the same with the organs of sensation.

I believe then that nerves are actually necessary to exterior sensations, whatever may be their nature. Let it be remarked, that all the organs with which the external parts may be in contact, as the dermoidal system, all the organs of the mucous system, and those of the senses, are more or less provided with cerebral nerves. None of these receive nerves from the ganglions. This exterior part of the nervous system in animal life is very considerable; added to that part, which proceeds to the voluntary muscles, it will constitute nearly the whole of the system, which has but very few connections with the organs of internal life.

In respect to internal sensations, their phenomena are not so striking as in the former cases. That the brain is the central point of these sensations, as those which are external cannot be called in question; in fact, if by the influence of wine, opium, or by any other means the office of that organ be suspended, and acute pains affect the interior organs, they never can be felt. Thus in concussion of the brain, although the impressions of sound, light, and of smells, are conveyed as usual to the ear, eye, and nostrils, that remain uninjured, we are not sensible of them. But how are the impressions received by the interior organs conveyed to the brain? Here are different phenomena which cannot possibly be well accounted for. If we admit that the nerves are commissioned to transmit these impressions exactly as those experienced by the exterior organs: 1st. Some organs are very sensible to the slightest contact, which, however, are supplied with nerves hardly perceptible, as the medullary membrane in long bones; 2dly, Several organs, in which the cerebral nerves evidently penetrate, as the liver and the lungs, may be irritated, without causing apparently any pain; 3dly, The muscles of animal life, into whose structure so many nerves enter, and which, in respect to animal contractility, take such an active part, hardly ever cause pain when their texture is divided, without including in the division the nervous filaments by which they are penetrated; 4thly, Ligaments into which no nerves enter, produce (as my experiments have proved) the most violent pains when extended. It is the same with tendons and aponeuroses, &c.; 5thly, Every organ in the structure of which the nervous system is evidently not concerned, will, however, when inflamed, convey to the brain the most painful sensations, &c. &c.

I could bring forward numberless other facts which the antagonists of Haller have so carefully collected; but these already noticed are so convincing, that we cannot but acknowledge that the opinions of that eminent physiologist, should not be unconditionally admitted.

All we know in respect to internal sensations is; 1st, That there exists an organ in which resides the cause of sensation; 2dly, That this organ transmits to the brain the particular modifications its vital powers undergo; but we are perfectly unacquainted with the means of communication between the one and the other. It is on this account, that in my division of vital powers I have laid aside all systematical basis. The distinction of two species of sensibility, and of three species of contractility, rests entirely on the observance of facts; such is the obscurity in the phenomena of life, that I doubt, if from knowledge of nature, of the essence of vital powers, we can ever establish divisions.

I observe, that between animal sensibility and contractility, this essential difference exists: in the first, the nerves are evidently in some cases the agents of communication between the organs that receive the impression and the brain which perceives it; but in other instances, we are ignorant of the connection; whilst, in the second case, it is evidently through the nerves that the brain communicates with the muscles, and the organs cannot perform a voluntary motion without the influence of the cerebral nerves.

Let us confine ourselves to this general fact, which is derived from strict observation; let us lay aside all reasonings, whenever their basis is not founded on just experience. Some modern authors have not been so judicious; they have admitted of a nervous atmosphere extending more or less, and acting in a determined distance; so that, although an organ is not supplied with nerves, it suffices that it is within the atmosphere of a nervous cord, to become the seat of sensations. This ingenious idea of Reil may be classed with the number of those which Bordeu has mingled in his works, and which bespeak more the genius of the author than a correct and judicious mind, averse to all opinion that has not a strict experience as its basis. In fact, what is this atmosphere? Is it a constant emanation from the exterior part of the nerves? Is it a fluid independent of them, and with which nature has surrounded every nervous thread, in the same manner as she has encircled the globe with atmospheric air? Is it a power that has been given to nerves, to act at a distance, without any intermediate agent? It is true that some experiments in galvanism have seemed to prove something similar in nerves; but these experiments bear no relation to the transmission of animal sensibility; besides, whenever pain is created in the centre of a very thick tendon,—in that of a large joint, (in that of the knee, for instance) it would then be requisite that the atmosphere of nervous activity should sometimes be extended to an inch in diameter. Why do we not feel pain when an insensible part, adjoining next to the nerve, and even fixed to it, is irritated, whilst it is very acute in a part labouring under inflammation, although this may be at a great distance from the nervous cord? The nerves in that case would also possess a sphere of activity in respect to motion. But why is not the contiguity of the nerves sufficient to produce it in the muscles? Why is this the case in respect to sensation?

Animal Contractility—Influence of the Nerves on that of other Parts.

The texture of nerves is completely deprived of this kind of contractility. In these no kind of sensible motion has been observed. They take, however, an essential part in this property, considered in respect to the muscles of animal life. We shall see that they are the essential agents that convey the principle of motion; so that animal contractility always supposes three actions successively performed; namely, that of the brain, that of the nerves, and that of the muscles.

Physiologists are of very different opinions respecting the manner in which the influence of the nerves is propagated. Some have admitted a kind of vibration; others a fluid which runs through the insensible canals of these organs. This last hypothesis is still very much accredited. What has not been said respecting the albuminous, the electric, the magnetic, &c. nature of this fluid? The chapter on nerves, in most of the treatises on physiology, is almost entirely devoted to the examination of this question, which I shall not here consider, because I have nothing to produce supported by experiments. Besides, cannot we study and analyse the phenomena of the nerves, without being acquainted with their mode of action? It has been the fault in all the ancient authors, to begin where we must ultimately leave off. The science was still in its infancy, when every question that was agitated turned upon the primary causes of the vital phenomena. What has been the result? A mass of absurd reasonings, and, finally, the necessity of returning to a strict observation of those phenomena, and of laying aside their causes, till sufficient information to establish theories had been obtained. Thus have they disputed for ages on the nature of fire, of light, of heat, and cold, &c. till at last philosophers have felt, that before arguing, it was unavoidable to found a basis for reasoning. This they have sought for, and have given birth to experimental physics. Thus have the schools been agitated by interminable disputes on the nature of the soul, on that of understanding, &c. until metaphysicians have been convinced, that instead of inquiries after the nature of our intellectual faculties, their operations should be analysed. Each of the natural sciences has had almost two epochs; that of the latter ages, in which prime causes were the only objects of discussion; a perfect void in the advancement of science. 2dly. That when they began to be composed of the study of such phenomena only as are demonstrated by experience and observation. Philosophy has still one foot in the former epoch; whilst she has already placed the other in the second. It remains with physiologists to complete the step.

Properties of Organic Life considered in the Nerves.

These are generally not very striking in these organs. Sensible organic contractility is wanting. Insensibility and organic sensibility are only to a certain degree necessary to nutrition; for these properties can answer no other purpose in the process. Let it be also remarked, that all the diseases of the nervous system are generally defects in animal sensibility, and that very few admit of a disturbance in the organic. There is scarcely ever an alteration in the nervous texture; no tumours, no fungouses, ulcerations, &c. as are found in such systems in which the organic properties predominate. Thus has pathological anatomy very little to do with nerves.

The habitual motion of a part, may occasionally increase a little the organic sensibility of the nerves which cross it, rendering their nutrition a little more active, and rather increasing their volume; but in general, this phenomenon is infinitely less remarkable than in the muscles. On the other hand, although nerves have been deprived of the power of transmitting sensation and motions, especially the latter, they still preserve, for a considerable time, the same degree of organic sensibility; and nutrition fulfils its office as usual.

I have several times, in hemiplegia, compared the nerves of the sound side with those of the affected one, and have found no difference in them. It is only in cases where a limb is ultimately afflicted with atrophy, which does not generally take place but after a very considerable lapse of time; it is only in such cases, I say, that the bulk of the nerve is diminished.

I have also frequently inquired, if, when a part in which there are nerves, and which for a long space of time has been the seat of uninterrupted painful sensations, the process of nutrition is affected; and consequently, if organic sensibility is deranged. I have dissected the stomachic cords in cancerous pylorus, the uterine nerves in those of the womb, and, excepting in two subjects, in whom they were rather increased, could never perceive any difference. Desault has also found, in a subject afflicted with carcinoma in the fingers, the median nerve of an increased size;

but this phenomena is not general, as, for instance, the dilatation of arteries in these same kind of tumours. In respect to acute pains, as those of rheumatism, of different inflammations, &c., let them be ever so severe, they will never affect the nutrition of the nerve that may serve to convey it, even when pain exists in the very nervous system itself, as in the tic douloureux there is seldom any organic injury. At least, Desault has had an opportunity of dissecting two subjects affected with this disease, in which the nerves were similar to those of the opposite side. This, however, requires a more accurate examination, because it may happen, that in several instances, the internal substance of the nervous cord is a little injured; for I have the sciatic nerve of a subject who had experienced the most acute pains along its course, and which exhibits in its superior part a number of small varicous dilatations proceeding from the veins, by which it is penetrated.

Influence of the Cerebral Nerves on the Organic Properties of the other Parts.

Do the cerebral nerves influence the organic sensibility of other parts?—I believe not, and this is the material difference by which it is distinguished from animal sensibility, so little understood, particularly in its natural state and in the external sensations, without the nervous influence intermediate to the brain, and the part which receives the impression. To prove this assertion, let us examine the functions that depend upon organic sensibility. They are, 1st. circulation in the capillary system; 2dly, secretion; 3dly, exhalation; 4thly, absorption; 5thly, nutrition. In all the phenomena of these functions, the fluids produce upon the solids an impression with which we are not familiar, and in virtue of which these solids re-act. It is through the means of organic sensibility that solids receive the impression; it is through insensible contractility they re-act: then, in none of these cases do the nerves appear to take an active part.

1st. Capillary circulation is carried on in cartilages, tendons, ligaments, &c. where the nerves of animal life do not enter. Inflammation, which is nothing else but a defect, an exaltation in this capillary circulation, takes place in these organs as in those that are more essentially provided with nerves. Nay, where nerves are more abundant, this affection is not frequently met with: of this the muscles are an example. The tongue, whose surface receives nerves four or five fold more than the same extent of a mucous membrane, is not so liable to inflammation as the other parts of that system. The retina that is entirely nervous, is seldom inflamed. Nothing, as I have stated, is more rare than inflammation of the nerves. The interior substance of the brain is scarcely ever inflamed. On the other hand, examine the serous surfaces of the cellular membrane, where there is only a very minute portion of nerve; on every occasion the capillary circulation is increased, and inflammation ensues. In the limbs of paralytic subjects, in animals, when you have divided a nerve to cause insensibility in a part, is not the capillary circulation carried on as actively as before, where nervous action has ceased? Have we ever accelerated this circulation in a limb? Have we ever produced inflammation in that part by convulsively increasing, through irritation, the nervous action of the limb? Convulsive phenomena, and those of palsies, are perfectly distinct; they bear no analogy with those of inflammations, which, however, would unavoidably be the case if they were influenced by the cerebral nerves. In the phenomena first mentioned it is animal sensibility that is injured; in the others it is organic. This then is evidently independent of the cerebral nerves.

2dly. Exhalation is the second function over which this last property presides. I refer to the system of the Dermis, to ascertain that perspiration is independent of the nerves. Here I shall merely observe, that in the synovial membrane, where a very striking exhalation is carried on, there are scarcely any nerves; that the serous membranes and the cellular membranes, so very remarkable for this function, are, as I have already mentioned, nearly deprived of them; that every time accidental exhalations take place, as in cysts, in hydatids, &c., nerves evidently have no kind of influence, since such tumours do not possess them; that by acting in any manner whatever on the nervous system, by irritating the nerves, the brain, or the spinal marrow, to excite this system; that in tying or dividing the first, or in submitting the second to compression, to lessen its action, or to annihilate it, we can never disturb, in any way whatever, the cellular, serous, synovial, or cutaneous exhalations; finally, that the diseases of the nervous system can never have any other influence over this function but that derived from general sympathies.

3dly. The same may be said in respect to absorption, it is during sleep, that the skin often absorbs most readily; in this case, there really exists a kind of discontinuance of action, as well in the nervous system, as in that of the brain; this intermission, to which it is periodically submitted, ought to produce a similar one in all the serous, synovial, and medullary absorptions, &c.: however, they are still continually carried on. It is the same in respect to all the functions over which organic sensibility presides; they are actually continued, although the nervous and cerebral actions are essentially intermittent.

4thly. The same observation appertains to the secretions, notwithstanding what Bordeu has said in this respect. For more, on this head, I shall refer to the glandular system.

5thly. Nutrition exists, in parts which are evidently not provided with nerves, in cartilages, tendons, &c.; it is continued in paralysed limbs; in every instance, these changes are independent of the nervous system. Individuals that have this system the most predominant, and that are the most sensitive, are not those in whom nutrition is most active. Nutrition has never, I believe, in any way, been influenced by acting on the brain, the nerves, or on the spinal marrow. Marasmus is, undoubtedly, the consequence of all nervous diseases, but it is a phenomenon attending a number of other diseases. In palsies, the long rest, as well as the defect of nervous action, disposes to atrophy, for this continues a long time without being apparent. Who is not aware that after a lapse of two, three, and even four years, the affected limb is exactly equal to the sound one? Besides, natural nutrition is governed by the same laws as accidental nutrition, as those which take place in the formation of fungous and sarcomatous tumours, in granulations, &c.; and then it is very evident, that the cerebral nerves are not connected with these productions,—they never inclose any: a phenomenon very different from that which the arterial system displays, and which generally unfolds in a remarkable manner in these tumours; finally, we shall see hereafter, that nerves never increase in proportion to the parts they supply.

From all that has been stated, it is evident, that all phenomena, over which preside what are commonly termed the tonic forces, namely, organic sensibility and insensible contractility, are actually independent of the nervous action; that consequently, these properties would not be proper, like those of animal life, to force this action. Every kind of sensibility has its morbid phenomena, over which it presides. Inflammations, all kinds of suppurations, the formation of tumours, dropsies, perspirations, hæmorrhages, disorders of the secretions, &c. &c. proceed from changes in organic sensibility, whilst all kinds of spasms, convulsions, palsies, somnambulism, torpor, derangement of the intellectual functions, &c. &c.; in a word, all that in diseases tends to interrupt our communications with surrounding bodies, must be referred to changes in animal sensibility, or contractility, and bespeak a derangement more or less decided in the nervous system.

In general, the diseases which derange the functions of animal life are quite of a different nature from those which destroy the harmony of organic life; the characteristics, the progress, the phenomena, are in nothing similar. On the one hand, let us place injuries of the external senses, blindness, deafness, loss of taste, &c.; those of the internal senses, epilepsy, apoplexy, catalepsy, &c.; those of the voluntary motions, &c. On the other hand, fevers, catarrhs, &c., and the whole series of diseases which disturb digestion, circulation, respiration, secretion, exhalation, absorption, nutrition, &c.; and we shall perceive by what an immense difference they are separated.

Physicians make use of the words nervous influence in too vague a sense: if in physic, as in physiology, such expressions only as convey a correct and strict sense were admitted, this would not be so frequently made use of.

Nerves seem to have some influence, (hitherto little known) on the productions of animal heat. I shall produce some facts that relate to this influence, 1st. The tying of the nerve in aneurism is frequently attended with a sensation, torpor and general coldness of the limb. 2ndly. Sometimes in hemiplegias the temperature of the nerve affected is less than that of the sound one, although the pulse may be the same in both. 3dly. A remarkable irregularity of heat in different parts of the body is a characteristic in those fevers, the special seed of which is in the brain. 4thly. Animals in which the nervous system is most powerfully displayed, as quadrupeds and birds, are those especially in which the natural heat is the greatest. 5thly. I have known a person, in whom (after the cubital nerve had been divided by a piece of glass above the pitiformis) the ring and small fingers continued cold. 6thly. The compression of nerves, occasioned by the heads of the bone in luxations, frequently produces an analogous effect, &c. &c.

However, it is far from being the case, that heat is augmented whenever the action of the nervous system is increased, or that it lessens when this is reduced. There are as many cases in which the natural heat seems perfectly independent of the nervous system, as those in which they appear to be connected; so that in this instance, again, we are confined in accumulating facts, without being allowed to draw from them any general consequences.

Sympathies.

I shall divide what I have to say in respect to the sympathies of the nerves, in the same manner as what I have mentioned concerning their vital powers; that is to say, I shall first examine the connections of every nerve with the other parts, and shall then speak of the general influence of the nervous system in sympathies, and the part it acts in such cases.

Sympathies peculiar to Nerves.

In the connections between the nervous system and the other systems, there is no question respecting those which appertain to the muscles and the brain. In fact, these connections are very natural, because the one cannot be affected without the others being sensible of it. These three organs make but one in this point of view. Thus, the pulsation of arteries is always in unison with the action of the heart, &c. Every idea of a sympathy naturally excludes that of a natural connection in functions. Barthez has misled himself in this respect. I am only speaking of connections contrary to the rules of nature; of phenomena that take place between an organ and any part of the nervous system, which are not connected in the natural order of life. In this point of view, nervous sympathies are very numerous.

1st. Two nerves of the same pair will frequently sympathize together. In physic, the connections existing between the two optics are perfectly known. When one is deranged in its functions, the other is also frequently affected. In the ear, the eye, &c. this does not occur so frequently. It will sometimes happen in *nevralgies,* (an expression I readily patronise, as it was wanted in the science, to express a class of diseases in which each gender almost requires a particular name;) in *nevralgies,* I say, when a nerve is affected, the corresponding one becomes painful from sympathy. I have at present an instance of it; it is in a woman who is afflicted with sciatica of the left limb. In the changes of weather, the very same pain affected the course of the nerves in the opposite side. I ordered two blisters to be applied on the thigh first affected. The pain subsided at the same time in both, at the end of twelve hours. Thus, in order to remove pains that affect both eyes, it is often sufficient to pay attention to one only.

2dly. Two nerves of the same side will often sympathize, although proceeding from different trunks. Thus, an injury in the frontal has been several times attended with sudden blindness, by afflicting the optic nerve.

3dly. In other instances, the branches of the same trunk influence each other reciprocally. In such cases as when a branch of the superficial temporal is affected, in opening the artery, the whole face, which also receives its nerves from the fifth pair, becomes painful, &c.

4thly. On other occasions, the nerves do not sympathize with each other, but with other organs; in which case they influence these, or they are influenced in their turn.

I say, first, that they influence these. Thus, a nerve being irritated in any manner whatever, a variety of sympathetical phenomena takes place in the body. These are frequently seen in diseases. It is thus that in the tic douloureux, and in analogous diseases, in which the nervous tissue is particularly affected, the animal sensibility is sometimes increased in distant parts, producing those head-aches, those pains in the interior organs, and which only subside when the exciting causes have disappeared ; that on other occasions the animal contractility is increased, from which proceed the convulsions in muscles that do not receive branches from the affected one. In other instances, it is the sensible organic contractility that is observed to be sympathetically excited by nervous affections. Thus, in the access of pain in *nevralgies*, there are often spasmodic vomitings, and the action of the heart is accelerated, &c. The same phenomena may be produced by experiments. Thus, in acting either upon the superior or inferior extremities, by irritating them in any manner whatever, after they have been laid bare, I have frequently occasioned vomiting, or brought on convulsive motions in muscles totally unconnected with the nerves that were irritated.

In the second place, nerves may be influenced by diseased organs. Thus it happens, that in a number of affections, either acute or chronic, sympathetic pains spread themselves through the course of different nerves, particularly in the limbs. As animal sensibility is the predominant property of nerves, it is this which in almost every instance is produced by sympathy. Physicians have not distinguished with sufficient precision, the pains of the extremities proceeding from the nerves, from such as are seated in the muscles, the aponeuroses, the tendons, &c.

Influence of the Nerves in Sympathies of other Organs.

Authors are much divided in respect to the causes by which sympathies are maintained—how an organ that is by no means connected with another, and that is sometimes very distant, can so far influence it as to produce very severe disorders, and merely because it is itself affected? This astonishing phenomenon is frequently met with in a state of health. But in diseases, it is so prodigiously multiplied, that if each disease were divested of the symptoms that are not exclusively derived from the state of the function which is especially deranged, they would present a simplicity, as easy for the study of them as it would be productive of little embarrassment in their treatment. But scarcely is an organ affected, than all seem simultaneously to partake of its disorder; each in its peculiar mode being employed to repulse the morbific cause that is centred in one of them.

The greatest part of authors have thought that nerves were the general means of communication which bind the organs with each other, and associate their disorders. The anastomoses have appeared to them intended for no other purposes; and in consequence of this opinion, some have considered the brain as being always intermediately affected; others have rejected this opinion. The communication between the parts through the blood vessels has also been admitted as a cause of sympathies. Some have accounted for them from the continuity of the cellular membrane; others again from that of the mucous membrane. I shall not apply myself to refute partially these different hypotheses: I shall merely remark, that if one single instance of them is not applicable to every case of sympathy, it is because these aberrations of the vital forces have been regarded in a too general sense. It has been believed that they were governed by an individual principle, and this principle has been sought after. But to ascertain the cause which produced sympathies, it is indispensable to divide these as I have done the vital properties; because, in the same manner as each of these properties admit of distinct phenomena, so must the phenomena which put them in motion also differ. To make this distinction of sympathetic very palpable, let us suppose a diseased organ, the stomach for instance; it then becomes the centre, from which pass numberless sympathetical irradiations, and which excite in other parts, sometimes animal sensibility, as when head-aches take place at that time; sometimes contractility of the same kind as when worms in the stomach produce convulsions in children. In other instances, sensible organic contractility, which being increased in the heart by certain spasmodic pains of the stomach, brings on fever, frequently insensible organic contractility and organic sensibility, as when the gastric affections are sympathetically increased, secretions take place upon the tongue, and cover it with a mucous fur. There are then such things existing as sympathies in animal sensibility and animal contractility, in organic sensibility and organic contractility. This being granted, let us examine the causes of each.

1st, When animal sensibility has been sympathetically increased in a part, it does not always proceed from the nervous communications, for the organs in which the material cause of pain exists, as the tendons, cartilages, &c. are not provided with nerves; then it cannot communicate through them with those parts in which this pain is felt. On the other hand, we have noticed before, that it is still very uncertain that the nerves are the sole agents which convey the internal sensations to the brain: then it would be incorrect to say, that the afflicted organ first acts upon it through their means, and then re-acts on the part to which the sensation is referred, through those which are distributed there. Can it ever be admitted that the cellular membrane could become a proper agent for conveying pain, when that very texture is itself denied sensibility? It may also be remarked, that the parts that are the most abundantly provided with this membrane, as the scrotum, the mediastinum, &c. &c. are not those which sympathise the most. The same may be said of blood vessels, which, by their very nature, are unfit to propagate animal sensibility, and which besides are not always met with in every organ.

It would seem that all sympathetic pains are nothing but an aberration from the internal sensitive principle that conveys to a part a sensation, the cause of which resides in another organ. Thus, when the extremity of a stump causes pain in a patient who has undergone amputation, the principal skin that feels does actually suffer. But he mistakes the part from whence it proceeds; he refers it to the foot, which is removed. It is the very same when a stone irritates the bladder. It is the glands that feel the pain. Thus, all sympathy in animal sensibility is characterised by the perfection of the part to which we refer the sensation, and by the cessation of that sympathetic pain which ceases the moment that the cause operating elsewhere has been removed. It is then probable, that when a part is sympathetically affected, that the part which is the seat of the essential cause of the pain, first acts upon the brain, either by the nerves, or by some means we are unacquainted with, and that when this viscus has perceived the sensation conveyed to it, it mistakes this sensation, and refers it to a part from which it has not risen, or refers it at the same time both to a spot where it was produced, and to another where it does not exist; for this occurs very frequently.

These aberrations of animal sensibility then exist entirely in the brain. It is an irregularity, a disturbance in perception. This irregularity presents phenomena very analogous with the following. We often, (as will be seen) attribute to the skin a sensation of heat, although caloric is not given out from that organ in a larger quantity. We are well aware that the sensations of hunger, and that of thirst, are merely sympathetic, and that the causes which produce them in the natural state, do not in such instances rest in the stomach or intestines. The illusions of sight, hearing, and even of smell, are made familiar to us. Generally the irregularities of perception have not been sufficiently studied; those of memory, imagination, understanding, &c. have been analysed. These have been almost forgotten. They act the chief part in sympathies of animal sensibility.

2dly. Animal contractility, when it is sympathetically excited, always bespeaks nervous action; in fact, we shall find that this property cannot perform its office without the treble action of the brain, of the nerves that proceed to the muscles that move, and of the muscles themselves. When a muscle of animal life is put in action by the irritation of some distant organ, by the distention of the ligaments of the foot, for instance; this organ first acts upon the brain, which then re-acts, by means of the nerves, on the voluntary muscles, producing convulsions in them. I shall here also mention an experiment, by which I am convinced how much the cerebral and nervous influence is indispensable in the sympathies we are now examining. I cut all the nerves of one inferior extremity in divers animals. I have then irritated, in a variety of different ways, very sensible parts, as the retina, the pituitary membrane, the marrow of the bones, &c. I produced in that manner a thousand sympathetic phenomena; sometimes organic contractility, as vomitings, involuntary evacuations of urine, of fæces, &c.; at other times animal contractility in the muscles whose nerves had remained untouched: but these muscles from which they had been divided, were in no instance brought into action. I have very frequently repeated these experiments, which would undoubtedly have produced results, if, without the interference of the brain, the nervous communications could make the muscles of animal life contract. I have observed, in this respect, that in experiments on sensibility, sympathetic phenomena have not been sufficiently attended to. I even do not believe, that these phenomena have ever been the objects of any experiments on animals, previous to those of which I now produce the first results, and which I intend to multiply in other points of view. There are then two things existing in all sympathies of animal contractility, namely: 1st, The action of the suffering organ upon the brain, by means with which we are but imperfectly acquainted; 2dly, The re-action of the brain on the voluntary muscles. In this latter period of the sympathy, the nerves of animal life are always the indispensable agents.

3dly. The cerebral nerves, as well as the brain, are evidently unconnected with the sympathies by which sensible organic contractility, or irritability, are put in motion. In fact, if this were the case, it would be requisite that the affected organ should first act upon the brain, and that this viscus should re-act on the involuntary muscles: thus, when tickling brings on vomiting, this would require a double action of the skin upon the brain, and of the brain upon the stomach. The brain then influences the involuntary muscles. Whatever may be the irritation upon the nerves with which they are supplied, they remain untouched. Now, although the brain might be sympathetically affected, it would not re-act on the involuntary muscles; then cerebral nerves have nothing to do with the sympathies of sensible organic contractility. The continuity of the membranes is not a more certain cause; the following prove it :—It is well known that irritating the uvula will cause the stomach to contract ; then, as the mucous surface is exactly the same in the one case as in the other, this sympathetical phenomenon might be attributed to this circumstance. In consequence, I inflicted a wound in the lateral part of the neck of a dog ; I seized the œsophagus and cut it transversely ; the uvula was then irritated ; well, the dog, notwithstanding the breach of continuity, still made efforts to vomit. Let us then acknowledge, that we are perfectly unacquainted with the causes of sympathies of sensible organic contractility.

4thly. As much might be said in respect to the sympathies of organic sensibility, and of insensible contractility, we have ascertained that nerves have no kind of influence on these two properties ; that by acting upon them they are neither increased or decreased in any way whatever ; that their diseases never disturb the functions over which these properties preside ; that when they are sympathetically disordered, the nerves seem to act a neutral part in these phenomena. Thus, 1st. all sympathetic exhalations, as hectic sweats, peculiar serous infiltrations, almost spontaneously produced, &c. ; 2dly, all secretions of the same nature as those which take place in a variety of diseases, afford us examples, &c. ; all analogous absorption, triple functions, governed by the preceding properties, are evidently unconnected with the nervous influence of animal life; I might make the same remark in respect to vascular cellular influences, &c. We cannot certainly ground an opinion upon any solid basis, to explain in what manner these means of communication can cause perspiration when the lungs are affected, or salivation when the palatine membrane is irritated, &c.

From all that has been hitherto advanced, it follows: 1st, That the sympathies of animal sensibility would seem, in most instances, to be aberrations of the principle which perceives in us, and which then mistakes the part in which the causes of sensations are operating. 2dly. That the sympathies of animal contractility unavoidably require the interference of the brain; but that we are ignorant by what means the part affected acts upon that viscus, although we are perfectly aware how that viscus, when sympathetically excited, re-acts upon the muscles to make them contract. 3dly. That the causes of the two kinds of organic sympathies are completely unknown, and that a dark veil still conceals from us the agents of communication, which in this case connect the organs from whence the sympathetic influence is conveyed to the part which receives it.

It is this obscurity of the causes of sympathies, which (in classifying sympathies in this work, in which I examine them in each system of the organs,) has induced me entirely to neglect all hypothetical opinion. I have only paid attention to the natural divisions, to those pointed out by the vital forces, of which the sympathies are nothing more than an irregular action. Thus, in confining ourselves to the most rigorous observation, it is evident, that this division is the only one that can be admitted; and, I believe, that no other can be employed until our knowledge becomes sufficiently extended, to authorise us in classifying them according to the causes from which they arise, and not from the results they afford.

Besides, I could not too strongly recommend, to distinguish perfectly that which belongs to them, from what belongs to the natural connections of functions. Let us only observe, what takes place in cases of syncope, of apoplexy, and of asphyxia; one organ is diseased, and instantly all the others cease to act. Have sympathies no part in these phenomena? Physicians have been much at a loss to classify these affections, which they have attributed, sometimes to nerves, sometimes to the vascular systems, &c.: but the following is what takes place in each of these cases. 1st. In every case of syncopy, whether it be owing to passion, to an offensive smell, &c. the heart first ceases to act; the circulation being stopped, the brain is no longer excited by the blood, its action ceases, and the whole animal life is interrupted; the organic life kept up by the blood is also instantly annihilated. 2dly. Asphyxia begins in the lungs, respiration becomes obstructed, it conveys to the brain a blood unfit to excite it, this viscus no longer corresponds with the senses, to determine the involuntary motions, &c. &c. 3dly. It is in the brain, that the immediate cause of apoplexy exists, and animal life is in consequence speedily interrupted; when also, the attack is violent, the brain having lost the power of acting upon the intercostal muscles, their movements are stopped, the mechanical, and then the chemical actions cease, the circulation cannot go on, and organic life is destroyed. It may then be perceived, that in all the phenomena of such affections, the injury sustained by one organ, induces, by a natural consequence, the suspension of action in the others.

In sympathies it is quite different. Thus, the functions of the skin being suspended, sometimes the lungs, sometimes the stomach, or the intestines, may partake of the injury and become affected: These sympathetical phenomena may or may not take place; on the contrary, whatever may be the cerebral, pulmonary, or cardiac actions that are disturbed, it is impossible that the others should not be affected in consequence.

SECTION III.

Properties of Re-production.

Will nerves be re-produced when they have been divided? The experiments of several eminent anatomists evidently prove it. What is the mode of such re-production? However little we examine the results of these experiments, it will be easily perceived that it has nothing peculiar in respect to the nervous system, that it is a simple cicatrization analogous to callus in bones, to the cicatrization of the skin, &c. When a nerve has been divided, its two extremities inflame, the cellular texture it contains shoots forth new parts in virtue of the re-productive property which we have acknowledged it to possess; these parts coming in contact, contract adherences that re-unite the two divided parts of the nerve. As the cellular membrane, which is the uniting means, springs forth in the divided extremity of the *nevrileme*, so also does that which is intermediate to the cords; it partakes of the nature of the theca, and becomes a parenchyma of nutrition, whose mode of organic sensibility is analogous to that of the nerves, and whose vessels on this account deposit within it the medullary substance, which gives the nervous cicatrice a new appearance, and renders it similar in a tolerable degree to the very texture of the nerve. However, as the vegetations arising from the divided parts are not produced in a regular manner, there never can exist at the point of contact that same regular filamentary disposition as in the nerve itself: thus the canal of a long bone, although analogous to that bone, is never so regularly disposed in longitudinal fibres as the bone itself; thus, will a cutaneous cicatrization always exhibit an irregularity of organization, proceeding from the irregular mode which the parenchyma of cicatrization has adopted in its formation.

Cicatrization of nerves is then analogous to that of the bones. In the first place, inflammation; in the second, growth of the cellular membrane, which is intended to fulfil the office of a nutritive parenchyma; in the third place, adhesion; in the fourth, exhalation of the medullary substance in the parenchyma: it is this medullary substance that causes this cicatrization to differ from that of bones in which the calcareous phosphates and gelatine are deposited, and that of the muscles which is penetrated by the fibrine: sometimes at the point of union in the nerves there is an excrescence in the form of a ganglion; this proceeds from the greater increase of the cellular membrane. Thus, the callus of bones is sometimes protuberant, on other occasions, if the parts have been in close contact, only a trifling difference is perceived. Such are the varieties, which alter in no respect, the natural process of cicatrization.

From all this it results, that the regeneration of the nerves, which of late has been a great object of research, and particularly demonstrated by Cruikshank, Monro, &c., present, as I have already mentioned, nothing particular in respect to the nervous system; that it is only a consequence of the general laws of cicatrization, and a proof of the uniformity of nature in all her operations, although these operations, at first glance, appear to afford different results. A nerve cut away in all its extent, could never re-produce itself in the same manner as the nails or the hair, which in length, form, and appearance, are exactly similar to those of the divided parts, &c. It is in the point of view we have presented them, and not in this last, that the re-productions of nerves should be regarded.

ARTICLE IV.

Developement of the Nervous System of Animal Life.

SECTION I.

State of that System in the Fœtus.

The nervous system of animal life is amongst those which are first developed. If the heart is the first to move, the brain is the first that acquires a considerable volume. The disproportion between the head and the other parts is very striking in the first stage of conception. Its size, compared with those of a subsequent age, is monstrous. Now it is evident, that it is the brain by which this is determined; that the bones and membranes that infold it are indebted to this substance only for their early extension.

One might be induced to say, that nature, in thus creating first the heart and the brain, and in causing their developement to precede that of the other organs, intended to form a basis for the organization of two lives; for in one instance it is the brain that is the centre of animal life: to this centre all sensations are referred; from this viscus all voluntary motions proceed. On the other hand, in propelling blood towards all the organs, the heart evidently presides over circulation, the secretions, exhalations, nutrition, &c., which in their mass compose organic life. When once these two essential bases have been laid nature begins to build, or rather to develope around her, the double organic edifice, which, on the one part, must enable the animal to communicate with external bodies; and, on the other, provide it with nutritive substance.

Notwithstanding this early developement, the brain is not, as the heart, in a state of permanent activity; its two essential functions, in respect to sensation and motion, hardly exist. For this reason the intellectual functions are so very obscure, that it is still a doubt if they have really commenced; the brain may then be considered, in some measure, as in expectation of the event, it does not act; it requires to be excited by external bodies. I do not, however, mean to say, that it is in a state of complete inaction. It may undoubtedly perceive certain motions which take place inwardly, and particularly the sensations of pain that are produced there: for if organic defects are observed in the fœtus, if it frequently dies in the womb of the mother, why should it not suffer by her diseases? Perhaps the brain perceives pain with so much more facility, as it is not diverted by the external senses. We have seen that the first are constantly conveyed through the means of the nerves, and that in the second this mode of transmission is doubtful. On the other hand, the phenomena, the sensation, the impression, &c., are not in both, so that the examination of their connections and of their distinctions is indispensable. This examination will have considerable influence in respect to the knowledge of the kind of animal life the fœtus may enjoy. Whatever this may be, it cannot be doubted that it is infinitely more limited than after birth.

The softness of the brain is excessive in the fœtus; it may rather be considered as a kind of softish fluid, which st the arteries, or rather the exhaling vessels that arise from them, deposit in their intervals. These arteries are then excessively numerous. Thus it is that the brain is strongly tinged with a reddish hue. If cut into slices, numerous streaks of the same colour are seen in its substance. The cortical and medullary parts of that substance are afterwards much less distinct, because the latter is not quite so white. At this stage of life it is readily dissolved, by means of caustic alkali. Its first effect before complete dissolution takes place, is to convert the cerebral substance into a glutinous, viscous, and transparent matter, of a reddish hue, and ropy, almost like the white of an egg. I have observed nothing similar in my experiments upon the brain in the adult subject, under the same process. Acids coagulate the cerebral substance in the fœtus, which, however, is not rendered so hard as at a more advanced age.

The excessive softness of the brain in the fœtus renders its dissection very difficult.

The nerves of animal life have a proportional increase with that of the brain. They are all very remarkable in size, compared to the other parts. Thus the fœtus, and the infant, when not too young, are fit subjects for the study of the nervous system, which is rendered more obvious by the slight developement of the other system. Their medullary substance, like that of the brain, and of the spinal marrow, is excessively soft, even dissolving under the finger, as may be seen on the anterior part of the optic nerve, where it is very striking, although inclosed by the ducts of the theca; in the posterior part of the same nerve; in the olfactory, in which it is seen in an insulated state; in the auditory, where it predominates; and finally, in the very origin of each pair, where its proportion in respect to the theca is strongly marked. In all the other nerves, this examination of the medullary substance is attended with much more difficulty, because the sheath that contains it is as much, or even more, developed in proportion, than it will be at a subsequent period. This explains why nerves have already acquired so much hardness and resistance at that early period, why they can sustain proportionally very heavy weights. Maceration in water at a moderate temperature, increases that resistance as it does in the adult, and renders it very hard, without augmenting its volume. It might be said this fluid acts upon the theca in a manner different to that which it pursues with other animal substances; finally, it also softens it, and it dissolves. The blood vessels are proportionally much more considerable in the nerves of the embryo than in those of the adult. Thus the whitish appearance of the latter has a livid tinge, proceeding from the kind of blood by which they are supplied. It is the very same phenomenon which occurs in the brain.

The developement of the cerebral nerves in the early age, displays a phenomenon which distinguishes them essentially from those of the arteries. In fact, these always increase in proportion with the parts to which they proceed. Thus the face, more imperfectly formed in the fœtus, has smaller arteries. It is the same in respect to the viscera of the pelvis, where the arteries being very diminutive, can only admit a small quantity of blood, which does not enter into and dilate them, until the umbilical arteries are closed. The volume of the cerebral and gastric arteries on the contrary is very considerable. The increase then of the nerves is perfectly independent of that of the parts in which they are distributed. The olfactory nerve, whose organ is so contracted in the fœtus, has the same proportion as the optic or the auditory, whose organs are already considerably expanded. It is the same in respect to all the nerves of the voluntary muscles; their increase is uniform, although the muscles vary in size according to their situation. If, without regarding situations, the nervous systems, the cerebral and muscular in animal life, be examined in a comparative and a general light, it will be perceived that the first essentially predominates, whilst, in the male adult, the muscles proportionally to what they were in the fœtus, have the preponderance over the nerves by which they are supplied. The par vagum, which proceeds and ramifies in organs whose growth is not in the same degree, present, however, the proportion that is afterwards seen in its divers branches.

These opposite dispositions of the arterial and nervous cerebral systems, prove, on the one hand, the immediate connection of the first with growth and nutrition; on the other, how slightly these are influenced by the second. The nerves, as well as the brain, are principally inactive before birth, although they present considerable developement. To this must be attributed the constant absence of all affections at that period.

They exist invariably in the fœtus, whilst the latter organ, and even the spinal marrow, are sometimes wanting, which constitutes the acephali. I shall afterwards explain how the fœtus can exist in this state, and at present I shall merely remark, that the heart, the liver, and the other essential viscera of organic life, on the contrary, are rarely deficient in the fœtus. Why? Because all the organs of that life are necessary for the purposes of growth and nourishment, and because these phenomena may very easily take place without the influence of the brain, this being principally intended to preside over animal life, which is not especially required to fulfil its office until the period of birth.

SECTION II.

State of the Nervous System during Growth.

At birth, the nervous system of animal life undergoes a remarkable revolution, in consequence of the blood by which it is penetrated; until that event black blood only circulates in its vessels. The speedy difference which the circulation undergoes must evidently influence its functions. In fact, if the least foreign substance differing from the red blood be propelled during life towards the brain, by means of the carotid, it is sufficient to cause very material mischief, and frequently even death itself, as I have very often ascertained in my experiments. Why? Because it is not only as a vehicle of the nutritive substance that the fluid which is impelled by the arteries acts upon the brain, but also as an excitating agent, as a stimulant. The change in excitation which the brain suddenly experiences at birth must unavoidably increase its vital activity, endow it with a new one, and render it fit for functions which it could not fulfil before those of perceiving sensations.

Asphyxia really exists whenever the lungs are not inflated after birth, when they are not filled with air, and consequently do not send red blood to the brain. Some motions in the muscles may undoubtedly be perceived; but animal life never begins completely until the organs that perform it are influenced by the red blood. This blood is a general cause of internal excitement; this direct excitement acts simultaneously with the sympathy which the brain experiences from the skin, and the mucous surfaces which exterior agents instantly excite, when the fœtus is expelled.

At that epoch it is then correct to say, that the lungs and the brain influence each other, the former by conveying red blood to the second, by exciting to action the diaphragm and the intercostal muscles, which force into the other that portion of air indispensable for the reproduction of red blood. From this we perceive that the other excitements are prior to that of this blood, since, before its formation, the brain must have been a principle of motion.

However, the brain and the whole nervous system are so much more powerfully excited by the additional principles the blood has borrowed from the air; because, 1st. Their vessels are proportionally more extensive, and more numerous than afterwards; because, 2dly. All the cerebral arteries resort to the side of the basis of the cranium where, on one part, is the origin of nerves, and which on the other part is indisputably the most sensitive part in the whole organ.

There is undoubtedly a very material difference between asphyxia which occurs in the adult, and the state of the fœtus; since if the first be continued, organic life ceases, whilst this life is all activity in the fœtus. Thus the dark blood of the arteries in asphyxia, and that in the arteries of the fœtus, by no means bear any resemblance with each other in their composition; however, a kind of analogy actually does exist in these two cases, particularly in respect to the remarkable diminution, or even the total absence of animal life, which characterises both. Thus, in producing at option, asphyxia in an animal, by means of a cock adapted to the trachea, I have always observed this life to sink in proportion as the black blood penetrates the brain, and when partly suspended, suddenly revive and re-appear; when, on turning the screw, I allowed the red blood to enter the brain, the nerves, and throughout the body. These experiments may then, in some degree, give us an idea of the part which the red blood acts at the epoch of birth in the developement of animal life; I say apart, because it is very far from being, as we shall perceive, the sole cause by which it is presented.

For a long time after birth, and even during almost the whole period of growth, the nervous system and the brain, which is its centre, predominate over all other systems by their developement; this kind of superiority, however, is not uniform at every epoch; it gradually decreases till the age of puberty, at which period the nervous system is put on a par with the rest, and the genital organs succeed to the superiority which it presented.

This predominance of the nervous system in the infant, influences on one part the sensations, on the other the voluntary motions.

The influence is strongly characterised. Infancy is the period for sensations. As all is new to the child, every thing strikes his eyes, his ear, his smell, &c. That which to us is an object of indifference, is to him a source of pleasure: as the man who suddenly finds himself in the midst of a scene with which he is unacquainted experiences the most gratifying sensations, but which are blunted by habit if frequently repeated. In fact, all the organs that receive external sensation, the nerves that transmit, and the brain that perceives them, are in reality in a state of permanent excitement in the infant, who, surrounded with the same objects as the adult, will fatigue his organs three or four times more than the last, to whom most of these objects are indifferent, because he has been previously excited by them. Let us remark that the periods of animal life are much shorter with the child who fatigues his organs in a few hours, with whom consequently a return of want of sleep is more frequent, and that intermission of animal life more profound. It rarely happens that infants during the first months of their existence can be kept awake the whole day, particularly if they have been struck with a variety of objects. By depriving them of light, sounds, &c. the state of waking might be prolonged.

The multiplicity, the frequency of sensations in an infant, necessarily compel him to a variety of motions which are not vigorous, on account of the weakness of his muscles, but which, like his sensations, are extremely numerous. As sight incessantly presents new objects to the infant, he is incessantly wishing to feel them; his little hands are in a constant agitation; his whole frame in constant motion. It was then indispensable that the nerves which serve to transmit this principle, should, like those of sensation, be adapted by this developement to the continual motion they display.

These two things, the great developement of the nervous system, and the frequency of its action in the infant, explain why diseases predominate at that age. Such at that time is the susceptibility of the brain to answer the sympathetic excitations, that however trivial the pains in any part may be, they instantly produce convulsions, which are at least four times more frequent at this than at any other subsequent age. I have observed, in this respect, that the various systems are (in the different stations of life) more or less disposed to correspond with sympathies, according as their predominance in the economy is more or less striking. The same morbific cause in any organ, and which in an infant will produce convulsions, by acting sympathetically upon the brain, might, in a young girl, cause a suspension of the periodical discharge, by influencing the womb, which begins to predominate; a peripneumony in a strong and vigorous youth; in the adult, as the gastric viscera predominate, an affection of these organs, &c. Thus it is that the very same passions that would cause jaundice or obstructions of the liver, &c. in the adult, in the infant would produce epilepsy, which attacks the brain.

Not only the nervous functions are frequently disturbed by sympathies in the infant, but it is particularly at that age that organic diseases are more frequently met with in the brain, spinal marrow, the nerves, or in the organs that depend upon them. The cerebral fungous, hydrocephalus, spina bifida, &c. are a manifest proof of this. The large quantity of blood which is then conveyed to the nervous system has a great influence on this phenomena; and this remarkable quantity itself is solicited by the predominance of the vital forces.

As the infant grows, the nervous system, and the brain, which is the central point, gradually lose that predominance which characterised them. Their diseases become less frequent; and finally, they are reduced to a level with the other symptoms.

SECTION III.

State of the Nervous System after Growth.

At the age of puberty, the empire of the brain, which has been insensibly effaced, gives place to that of the genital organs, which display a sudden increase. The cerebral nerves have appeared to me to possess but very little influence upon their developement, as well as upon that in the greater part of the other systems. In fact, let us observe, that all the phenomena of generation are over-ruled by the organic forces, which, as we have already noticed, are perfectly independent of the nerves. Thus the strong excitement of the genital organs, from which satyriasis, nymphomania, &c. proceed, have no kind of analogy with convulsions, whose principle is in the brain, as the privation of sexual appetite is absolutely unconnected with palsies. This is so very correct, that frequently in those which affect the inferior part of the body, in consequence of a fall on the sacrum, or from any other cause, venereal desires and the emission of the seminal fluid occur as usual.

After the age of puberty, and towards the middle stage of life, when a general equilibrium is nearly established between the different systems, that of the nerves does not experience more than what we have mentioned in treating of this subject.

SECTION IV.

State of the Nervous System in Old Age.

At this stage of life, the nervous cerebral system has but an indifferent task to fulfil. In fact, in respect to sensations, these are so far blunted by habit, that external bodies produce but very little impression on the organs of our senses; several of these, as the eye and the ear, become insensible before general dissolution. The nerves have then but little to transmit, and the brain but little to perceive. In respect to motion, the old man performs few, because he feels little; for to feel and to move are qualities that are generally combined in equal proportion. The brain and the nerves then are in this respect nearly inactive. The former is no longer excited by the intellectual functions, memory, imagination, judgment, attention, &c.; all is on the decay, and acts only in an obscure manner.

Alterations of structure constantly harmonize with those of the functions. In the fœtus, the brain was almost in a fluid state; in old age, it is extremely firm. Between these two extremes of age, that organ has passed through innumerable graduations.

It is well known, that anatomists always prefer the brain of an elderly subject for the purpose of studying this viscus, whose parts are so easily lacerated. I have observed, in this respect, that what is natural at that age, bespeaks in youth a morbid affection. In general, the comparative anatomy of the systems in the differences of ages have not yet been sufficiently examined to enable us to make applications in dissections.

Blood-vessels lessen in the brain in proportion as its density increases. In this respect, again, it exhibits an inverse disposition to the two extremes of life. In old age, its hue darkens. Ossification seldom takes place; however, there are some instances of it. The phenomena presented by the effect of divers re-actives are produced with much greater difficulty than in the adult subject, and particularly in the infant. Dissolution, by means of alkalies, is a remarkable proof of this.

It cannot be doubted, that this organic state of the brain at the approach of decrepitude has the greatest influence on the preceding phenomena: to this, likewise, must be attributed the dullness of painful sensations at that age. A cancerous tumour in an elderly subject, perfectly analogous in its situation, its shape, volume, and nature, to that in an adult, does not cause the same degree of pain. Cancers in the womb, in the stomach, in the breast, &c., are striking instances. In the numerous experiments which I have made on living animals, I have constantly ascertained that the young ones, when sensible parts were divided, underwent the most acute pains; whilst the old ones, under similar circumstances, appeared to suffer much less. I cannot avoid making another observation in this respect: it is, that the breed in dogs seems in a certain degree to have some influence on the acuteness of their sensations. All the large species make but little noise, and are not much agitated, when their skin, their nerves, &c., are divided by the scalpel; whilst those of a smaller description, although aged, struggle, are agitated, and bespeak the greatest pain from the most trifling causes.

In respect to the influence of age upon painful sensations, it is not at all astonishing that animal sensibility, having become very obscure in the natural state, preserves the same character in that of disease. Then it is evident, that an elderly subject, under the influence of the same causes, suffers less than an adult, and much less still than the infant; this is a kind of compensation for the deficiency of his enjoyments. In every thing that strikes the infant, he finds a cause of pleasure, or of grief; thus, a smile or tear, succeed each other with the utmost rapidity on his delicate features. The elderly subject, on the contrary, remains always calm. Indifference is his natural state.

Nerves undergo the same changes as the brain, they are gradually hardened by age; however, their degrees of induration in the two opposite stages of life are much less striking than that of the latter organ: this depends upon the theca or *nevrileme*; for it does not seem applicable to the medullary substance.

This medullary substance has appeared to me less abundant in the optic nerve of old persons; in other parts, the quantity is not so easily ascertained. The colour of the nerves tarnishes, like that of the brain; they admit a smaller number of vessels, and are never ossified.

It is sometimes said, that the extremities of nerves become callous: a vague expression indeed, to which we have never been able to attach the least sense. When will medical language be no longer an index of the defect and incorrectness of the hypotheses of which it was formerly composed? The greater part of these hypotheses have passed away, and yet almost all the expressions to which they have given birth still remain.

In old age, the nervous system and the brain lose in advance a part of their functions: from this proceeds hemiplegia, which at this age is almost as frequently met with as convulsions, their opposites, are in the infant. These senile hemiplegias must be distinguished from those which affect the adult; they are of the same nature as the senile cecity and deafness, the distinction rests only in the injury to sensation, or to motion.

NERVOUS SYSTEM

OF

ORGANIC LIFE.

General Considerations.

No anatomist has as yet considered the nervous system of the ganglions in the point of view I am going to represent them. This consists in regarding each ganglion as an insulated centre independent of the others, by its re-action distributing and receiving its particular nerves in the same manner as the brain receives and distributes its own, having nothing in common but through anastomosis with the other analogous organs; so that there is this remarkable distinction between the nervous system of animal and that of organic life, that the first is a single centre, that it is to the brain every kind of sensation is conveyed, and from it, that every kind of motion proceeds; whilst, in respect to the second, there are as many insulated centres, and consequently as many small secondary nervous systems, as there are ganglions.

It is well known that all anatomists, even those who, without attributing a strict sense to their expressions, have designated ganglions by the appellation of diminutive brains, have mistaken them for appendages, for swellings of the nerves, in whose course they are found; and as the greatest part of them are found in the great sympathetic, they have been represented as a distinctive characteristic of this nerve. But from the general idea I have just given of ganglions, it is evident that this nerve in reality does not exist, and that the continued filament which is observed from the neck to the pelvis, is nothing else but a series of nervous communications, a series of ramifications which the ganglions, placed in a vertical manner, reciprocally exchange, and not a nerve proceeding from the brain or the spinal marrow.

The first considerations which induced me to believe that the great sympathetic is not a nerve of the same description as others, but only a series of anastomoses, were the following: 1st. These communications are frequently interrupted without occasioning any derangement in the organs to which the great sympathetic resorts. In several subjects, for instance, a very distinct interval is observed between the pectoral and lombar portions of this pretended nerve, which, in this part, seem divided, because the last pectoral and the first of the lombar ganglions do not communicate. I have frequently observed the sympathetic nerve to disappear, and again spring up from the same cause between two ganglions, either in the lombar region, or in that of the sacrum; 2dly. Every body is aware that the ophthalmic ganglion, the spheno-palatine, &c. are constantly found in an insulated state, and that they communicate by means of their branches with the cerebral nerves only; that the absolute deficiency of communication which is sometimes observed in these, constantly exists between those of the brain and the great sympathetic; 3dly. In birds, as Cuvier has ascertained, the superior cervical ganglion is always found insulated, it never communicates with the inferior one; the filament which in quadrupeds descends along the neck is wanting. In many other animals, we often find that this series of anastomosis from the ganglions, which compose what is denominated the great sympathetic nerve, is frequently interrupted. 4thly. The communications of ganglions generally take place by means of a single branch; but sometimes several proceed from one of these organs to the other, so that if the great sympathetic were a nerve similar to others, it would, in this respect, present quite a different disposition to that of the cerebral nervous system; 5thly. From whence does the great sympathetic proceed? From the sixth pair? Now were this the case (as all the nerves continue to diminish in proportion to their distance from the brain) its disposition would be quite opposite; it would increase in distributing its branches. Could it arise from the spinal marrow? Then the branches it distributes to one region would proceed from those it receives in that region. Thus the great and small splanchnic nerves would arise from some of the intercostals; but they are evidently much larger, particularly the former, than the whole of the branches from which they would originate. It may also be remarked, that all anatomists have been of different opinions with respect to the origin of the great sympathetic nerve; in fact, how could they have been unanimous concerning what does not exist?

These various considerations confirmed the opinion I had long entertained, that there is no such thing as the great sympathetic nerve; that the cord it forms is only a series of communications between small nervous systems placed one above another; and that these communications are merely accessory, and might perhaps be dispensed with, as we may constantly perceive between the ophthalmic and the spheno-palatine ganglions, between this and the superior cervical, many instances of which are supplied by many animals. From that time

I began to consider each ganglion as the special centre of a small nervous system, perfectly different from the cerebral, and even distinct from the small nervous systems of the other ganglions. In considering the functions of the nerves proceeding from these centres, I was still more convinced, that they in this respect belonged to the cerebral system. In fact, these nerves, as we shall perceive, have properties very distinct from the cerebral; they are not the agents of sensation; they are never connected with voluntary motion; they are only to be met with in the organs of internal life; and this explains why they are found concentrated in the trunk, particularly in the breast and abdomen; why scarcely any are found in the head, where almost every organ is dependant on animal life; and why the extremities which belong exclusively to animal life are not provided with them.

Distributed in almost every organ of interior life, the ganglions and their nerves must naturally partake of its character; this is, in fact, what is observed to be the case: 1st. They are not symmetrical. Thus the nerves, in every plexus of the abdomen, in the cardiac plexuses, &c. are very irregular; 2dly. There are innumerable varieties in the form of these plexuses, and in that of the ganglions; scarcely two are arranged alike. Thus the plexus that is beneath the diaphragm is sometimes of a lenticular form, at other times it is triangular, or it is divided into several portions. From thence the inaccuracy of all denomination drawn from the figure, a remark generally applicable to every organ of internal life. We might more judiciously borrow the names of forms in animal life, where the shapes are more invariable; and on the other hand, the number of several ganglions varies considerably; sometimes three are found in the neck, on other occasions only two. The disposition in one side ever commands a similar one in the opposite one. I have frequently ascertained that the number of filaments proceeding from the superior cervical ganglion essentially differ from those which arise from the opposite side. There are actually two analogous organs in each side, but innumerable distinctions in structure incessantly destroy the general character of symmetry. It is the same as in the lungs or in the loins. We might then lay down as a distinctive character between the two nervous systems, the regularity of the one, and the irregularity of the other; then this very characteristic, as I have already mentioned, is one of those by which the two lives are distinguished.

From what has been stated, it is evident, that a marked distinction exists between the nerves proceeding from the ganglions, and those from the brain, and that it would not be correct to view them as forming one sole nerve, emanating from the latter by any origin whatever. Their communications no more prove the existence of such a general nerve, than the branches that proceed from the cervical pairs, the lombar, or the sacral, to those which are either superior or inferior to them. In fact, notwithstanding these communications, we consider each pair in an insulated manner, we do not form a single nerve from the whole; in the same manner, every ganglion must be considered separately, notwithstanding the branches that proceed from it to others.

The description of the system of ganglions should be analogous to that of the cerebral nerves. For instance, I first describe the lenticular ganglion, in the same manner as we describe the brain; then, I examine its branches, amongst which is the great splanchnic; for that expression, which describes this nerve as giving birth to the ganglion, is very incorrect. In the neck, the head, &c. every ganglion also is first described; then its branches, amongst which are such as communicate. There are consequently almost as many descriptions as there are separate ganglions: we ought not, for instance, to treat of the ophthalmic nerve together with the general motores; to be convinced of this, it is only requisite to consider how much the ciliary nerves differ from the others, which, belonging to animal life, are also contained in the orbit.

In consequence of what has just been said, it is evident, that two things are to be examined in the nervous system of organic life: 1st, the ganglions; 2dly, the nerves that proceed from them.

ARTICLE I.

The Ganglions.

SECTION I.

Situation, Forms, Connections, &c.

Ganglions are small bodies, of a redish or greyish hue, situate in different parts of the body, and forming, as it were, as many centres, from which an infinite number of nervous ramifications project. They are most generally found along the vertebral column, where they are seen placed in succession one above another: the superior and inferior cervical, the intercostals, the lombar, and sacral. It is the branches of these, in particular, which, by communicating, form the great sympathetics; besides all these ganglions, arranged as it were in a row, some are found in different parts in an insulated state, as the ophthalmic, the spheno-palatine the maxillary in the head, the semi-lunar in the abdomen. In the chest there are none similarly disposed; sometimes, however, a small one is observed at the basis of the heart.

Besides the ganglions constantly observed, accidental ones, if I may be allowed the expression, are frequently met with; such are those sometimes found in the hypogastric plexus, even in the solar plexus, at a small distance from the semi-lunar plexus, in the middle of the neck, &c. On the other hand, some of those generally observed are wanting; for instance, some of the lombar, of the sacral, the maxillary, &c.; so that in respect to existence, there is certainly an essential difference between ganglions. The superior cervical, the semi-lunar, the ophthalmic, &c., are always present; they appear to be essentially necessary for the action of the organs, which they supply with nerves. On the contrary, the greater part of the others can be dispensed with, and the deficiency supplied by those around, or by others formed contrary to the usual anatomical order.

In general all ganglions are deeply seated; though unprovided with a bony covering analogous to that of the brain, they are not the less defended against the action of external bodies. It is this deep position which places them without the reach of our experiments; from such, at least, as may require that the animal should survive the operation for some time. This will undoubtedly maintain, for a long time, the obscurity in which the functions of these organs are still involved.

The form of ganglions is excessively irregular; in general they are somewhat round; occasionally they are elongated, and sometimes they form a kind of triangular body with obtuse and rounded edges, as the ophthalmic; in other instances they are of a semi-lunar form, as that which bears this name, &c. In general all these forms, as I have already noticed, are remarkably variable; the most constant is that of the superior cervical.

Imbedded in a great quantity of cellular tissue, ganglions are separated by it from the approaching organs. Almost every one of them are so situate that they experience but very little motion from these organs, and none whatever from the blood-vessels that resort there. Those situate along the vertebral column, present in particular this phenomenon very distinctly, both from that which takes place in the brain, whose functions are essentially connected with the continued agitation which is kept up by the motion of the blood in the part, and from that which is observed in plexus of nerves proceeding from these same ganglions.

SECTION II.

Organization.

In the adult, the ganglions are generally of a redish hue, very distinct however from that of the nerves; sometimes they are rather grey. On dividing them, they exhibit a soft spongy substance, somewhat similar, at the first glance, to that of the pretended lymphatic glands.

This texture has no resemblance to the cerebral substance, nor to that which exists in the ducts of the theca. These two last, as I have already mentioned, ought rather to be classed amongst fluids, being a pulp, a real pap; nor have they any of the properties of solids: they do not contract; the kind of hardness they acquire, resulting from the contact of alcohol, of acids, and of caloric, is very distinct from contraction. It is analogous to the induration of the white of an egg. On the contrary, the texture of the ganglions shrink in a very remarkable manner, a phenomenon that characterizes all the solids, excepting the epidermis, the nails, and the hair, which form a distinct class. Submitted to the action of acids, the ganglion, after being drawn together, shrunk and hardened, softens by degrees, and ultimately diffuses.

A phenomenon nearly analogous, is produced by concoction: 1st. Contraction and hardening at the moment of ebullition; 2ndly. Continuance of this state, for the space of half an hour; 3dly. Softening gradually brought on; when this is completed, the coction is finished. In this respect, ganglions are perfectly different from nerves submitted to the same experiment. I have also observed, that in veal they have a very different taste from the nerves, a mode of trial, which, (to appreciate properly the difference of nature in the organs) ought not to be neglected. In fact, as we are not yet acquainted with the various principles that enter into the composition of each, we must be satisfied with ascertaining the differences of qualities.

Alkalies act in some degree on the ganglions, which they tend to dissolve, and which they will actually dissolve in part, if they are very caustic. But this dissolution is attended with much more difficulty, and requires much more time, than that of the cerebral pulp submitted to the same trial. Ganglions resist putrefaction as long, and even longer than the nerves. This is another very remarkable difference between them and the cerebral substance. In general, it may be established as a principle, that there is no kind of analogy between them.

The texture of ganglions does not appear to be of a fibrous nature. A slight inspection will show that it does not possess the slightest linear or thready appearance. Homogeneous, in some measure, in its nature, when cut in slices, it presents, throughout, an uniform aspect. The celebrated Scarpa, however, has considered ganglions as resulting from a kind of expansion of the nerves, into an infinite number of very thin filaments, which interweave with each other, and become very distinct by maceration. I have not repeated all those dissections, which have appeared to me extremely difficult to perform. I shall refer then, to his work, and to the plates which he has added to it. I shall merely observe, that the ganglions, most undoubtedly, must contain something more than a single re-solution of the nerve into very thin filaments. In fact, the slightest glance suffices to establish betwixt them the utmost difference undoubtedly; a distinctive line should be drawn between ganglions and their nerves, as between those of the brain and of this substance. 1st. Difference of colour—being reddish and grayish in some, white in others; 2dly. Differences of consistence, of exterior qualities, &c.; 3dly. Difference of properties. If the nerves proceeding from the marrow merely expanded into very thin threads in their way through the ganglions, this would only constitute a diversity in the form, and by no means in the nature,—the properties would be the same.

Why, (as I shall afterwards prove,) are they so very distinct? Why, when a nerve escapes from a ganglion, is it no longer fit to communicate voluntary motion? 4thly. Why has not nature provided the nerves of the extremities with ganglions, as well as those of other parts? 5thly. If a ganglion be nothing more than the re-solution of a nerve into very diminutive filaments, why is there never any proportion between the filaments that enter into it on one side, and those which pass out on the other? In fact, those which penetrate the superior cervical from above, have no other office than to expand their filaments in this ganglion, and then to re-unite them to form those which project from the lower part. There should undoubtedly be some equality of volume between the one and the other; every ganglion should exhibit this constant connection between the nerves on one side, and those on the other; but, inspection will suffice to prove in almost every one of these organs, a disposition quite the reverse; 6thly. Ganglions ought, in every instance, to be proportioned to the size of the nerves that form them, by the expansion of their filaments. Why then, are the intercostal ganglions so small, and the trunks that unite them, or rather, by which they are formed, and project again according to the admitted opinion,—why are these, I say, so large? Why, on the other hand, is the superior cervical ganglion so large, and its branches so very small? 7thly. In what manner could we account for the frequent interruptions existing amongst the ganglions of the human species, and for those constantly ascertained in a considerable number of animals, if there were a continuation between the nervous filaments that enter into the ganglion above, and those which proceed from it below? 8thly. How is it that ganglions and their nerves do not follow in their developement an exact proportion with the cerebral nerves, if it be by the expansion of these that they are produced?—and 9thly. Why do not painful sensations bear the same characteristics in these two kinds of nerves?

I have formed no opinion in respect to the nature and the functions of ganglions, because I am unprovided with facts to support it; but most undoubtedly, their texture admits of something more than the mere expansion of the nervous filaments. Scarpa admits of a peculiar matter, which separates these filaments; but that substance ought then to predominate very considerably, since the bulk of the ganglion exceeds by far, that of the nerves to which its origin is attributed. Now, I have never seen this substance; I do not know what it is: divide a ganglion, and it is perfectly solid. I am then induced to believe, that in admitting, to a certain degree, the interior conformation, which that author has observed in ganglions, one might not consider these organs in the same light in which he has represented them.

The changes that ganglions may undergo from diseases are but very imperfectly ascertained. In diseases of the heart, of the liver, of the stomach, of the intestines, I have frequently examined the ganglions that give off nerves to these viscera: they did not appear to me to have undergone any change. In the worst cases of cancer of the stomach, when the whole of the adjoining cellular membrane is obstructed, and the lymphatic glands are considerably enlarged, I have constantly found the semi-lunar ganglion uninjured, excepting, however, one case, in which its volume was increased, and its substance rather more dense. In another instance, I found in a subject, brought to the Hotel Dieu for periodical madness, the same ganglion, the size of a filbert, and containing a small cartilaginous body in its centre. Several physicians have thought, and I am inclined to be of the same opinion, that hysterical fits, which begin with a contraction in the epigastric region, followed by the sensation of a ball rising to the throat, may proceed from some affection of the semi-lunar ganglions, of the soliar plexus, and of the communications from ganglion to ganglion extending to the neck. Two subjects, however, that I have lately dissected, have exhibited no alterations in these organs, although, during life, they had frequently laboured under such affections; but it is evident, they might proceed from the ganglions, and from the epigastric plexus, without these being affected in their structure, in the same manner as numberless cerebral diseases leave no trace in the brain. This point merits a particular inquiry.

It does not appear that the texture of the ganglion is surrounded by a peculiar membrane. The adjacent cellular membrane, only, is seen to condensate, and afterwards to acquire a considerable consistence and firmness around these organs. It there assumes the nature of the sub-mucous, sub-arterial tissues, &c.; and in no instance does it contain any adipose matter. Ganglions, then, as well as arteries, under the subjacent part, mucous surfaces, &c., are provided with the two kinds of cellular tissue, which we have mentioned in treating of the organization of that tissue, and which differ so essentially from each other, both in their nature and properties. It is the second kind, that is analogous to the sub-arterial tissue, &c. which constitutes the peculiar membrane admitted by some authors.

On examining attentively the interior of ganglions, we may also ascertain that they possess but a very small quantity of cellular tissue. I have in all instances always found it destitute of fat: Alkalies do not form a soapy matter, as around the cerebral nerves, when immersed in their solution.

I have submitted several ganglions to this experiment, on account of the opinion of Scarpa, who conceived that these organs were penetrated with this fluid, at least in corpulent subjects.

Ganglions receive a great number of blood vessels. These penetrate them on every side; at first they ramify in the kind of cellular coat which incloses them, then entering their substance, they divide and are lost in numerous anastomoses, and in continuation with the exhalants that convey the nutritive matter. Fine injections display a very great quantity of vessels in these little organs. Nutrition supposes within them the presence of exhalants and absorbents.

SECTION III.

Properties.

It is very difficult to analyze the properties of the tissue in ganglions. As to the vital properties they cannot be produced, exist, and be nourished, without organic sensibility, and insensible organic contractility. Animal, and the sensible organic contractility are not evident in these organs. In respect to animal sensibility: this is what I have observed on opening the abdomen of any animal,—of a dog for instance; he continues perfectly alive for some space of time, and even remains calm after the first moments of suffering. I have watched that state, which succeeds the agitation caused by the incision of the abdominal walls, then I have laid bare the semilunar ganglion, and have strongly irritated it; the animal was not agitated; whilst, as soon as I irritated a cerebral or lombar nerve, he cried, struggled, and attempted to rise. It appears, that in general, sensibility in ganglions is much less striking than that of many other organs; undoubtedly the skin, the mucous system, the medullary, the nervous system of animal life surpasses them in this respect.

Our ignorance of the diseases that are seated in ganglions, the distance by which these organs are secured from external stimulants, leave us completely in the dark in respect to their sympathies. I believe it highly probable, however, that these sympathies act a prominent part in hysteria, in some peculiar kinds of epilepsies, in which the fit commences, as in those of hysteria, with a painful sensation in the epigastrium; in those numerous affections denominated nervous, and which the vulgar confound under the appellation of vapours. One of the most important objects of research in nervous diseases, is to distinguish those, which have their special seat in the cerebral nervous system, from those which affect more particularly the system of ganglions. On the one hand, let us place palsies, hemiplegia, the convulsions of infants, tetanus, catalepsy, apoplexy, the greater part of epilepsies, the innumerable accidents proceeding from effusions or compressions on the brain, in cases of wounds on the head, affections of the sight, of hearing, of taste, of smell, &c.; and every affection, the seat of which is evidently in the head:—on the other side, let us place hysteria, hypochondriacism, melancholy, &c.; and that numerous class of affections, of which the abdomen and the chest, but particularly the former, appear to be the centre from whence they proceed; we shall then see that there is an essential difference, and that the symptoms bear quite a distinctive character. I do not mean to say, that the latter genera belong exclusively to the ganglions; because these affections are, as yet, involved in too much obscurity to give any decided opinion, either with respect to their seat, or their nature. The secretory, circulating, and pulmonary organs, &c., may then be specially affected in their peculiar membranes, and independently of the nerves they admit; but it is certainly a most interesting object of research, and there is too great a difference between the phenomena of both these orders of affections, for their primary seats to be the same. It is difficult to believe, that the system of ganglions are not materially connected with the latter.

What induces me to believe that the difference of the phenomena which the general order of nervous affections present, is owing particularly to that of the cerebral nerves and those of the ganglions, is, that their phenomena in the state of health are very distinct. Hallé has very judiciously observed, that the painful sensations we experience in such parts as receive nerves from ganglions, have a peculiar character; that they do not resemble those experienced in such parts as are supplied by the cerebral nerves. Thus, the painful sensations of the loins from affections of the womb, from vinous injections of the tunica vaginalis, &c., a sensation that seems to me to arise from the sympathetic influence of the affected organ on the lombar ganglions; thus, the acute pains in the intestines, the sensation of burning in the epigastrium, cannot be assimilated to the painful sensations experienced in external parts: they are deep, and go to the heart, according to the common expression. We are aware that there are such things existing as colics, which are essentially nervous, and which undoubtedly are quite independent of all local affections of the serous, mucous, and muscular systems of the intestines. These colics are evidently seated in the nerves of the semi-lunar ganglions, which overrun the whole course of the abdominal arteries; they constitute real nevralgies in the nervous system of organic life: then, these have positively no connection with the tic douloureux, the sciatica, and the other nevralgies of animal life. The symptoms, the course, the duration, &c. every thing, in a word, is perfectly distinct in both these affections.

What I have stated regarding the disorders of sensation, may also be applied to those of motion. We can make no kind of comparison between the convulsions of muscles which receive nerves belonging to animal life, and the irregular and spasmodic motions that arise in all muscles that are supplied with nerves from the ganglions. In affections of the heart, of the intestines, of the bladder, &c., there is nothing resembling tetanus; all these considerations form marked distinctions between the cerebral nerves and those of the ganglions; distinctions of which I can only speak superficially, since nothing is advanced respecting the functions of the latter.

SECTION IV.

Developements.

In the first stage of life ganglions differ essentially from the brain, their developement being much slower than that of this viscus. They have only the same degree of progression with the other organs, whilst the brain, in this respect, as we have ascertained, supersedes them all. In comparing the superior cervical and semi-lunar ganglions in the fœtus with those of the adult, this remark is easily made. In the fœtus, the ganglions are also less provided with blood-vessels, compared with the brain. They do not follow that proportional increase of the organs which they supply with nerves. Thus, those which supply the genital organs, and which are nearly overlooked during the first years of general nutrition, are, in proportion, as voluminous as those which supply the liver, the stomach, the intestines, so particularly characterized by their early developement. These nerves are, in this respect, submitted to the same law with the ganglions, although the greater part of them attend the arteries, which are more or less extensively developed in proportion to the organs which they penetrate.

The nervous system in organic life being less forward in its growth than that of animal life, must naturally, in the infant, be subject to fewer affections; and this indeed is ascertained. Convulsions, and the nervous affections of the second system, are the special appendages of childhood. On the contrary, the particular order of the nervous affections we have mentioned, and in which it seems the first acts the principal part, is hardly ever met with at that stage of life. All those nervous diseases, which seem to have their special seat in the epigastrium, so abundantly supplied with nerves by the ganglions, appear to be strangers to this period of life.

Another difference, that in respect to growth distinguishes the ganglions from the brain, is, that in the fœtus they are not so extremely soft as that organ. They possess nearly the same degree of solidity as in the adult.

As we gradually remove from infancy, the organic nervous system begins to predominate. It is about the age of thirty or forty that it seems to have attained its highest degree of action; it then gradually decreases as we become old, at which period it has partly faded away, the nerves assume a greyish hue, ganglions become hard, resistant, and smaller; the nervous affections which seem to belong to them are more rarely met with. Besides, the functions of this are still so involved in darkness, that we can only hint in a vague manner the alterations they undergo in the different stages of life.

SECTION V.

Remarks on the Vertebral Ganglions.

All I have said till now, in respect to ganglions, was the abstraction of those which answer, in point of situation, to the foramena; and which, by some authors, are called single ganglions. We are aware, that at the instant a nerve projects through the foramen, it exhibits an evident swelling of a reddish hue, pulpous, and analogous in its appearance to the greater part of ganglions.

I must confess I am rather at a loss how to classify these organs; it is impossible to deny but that they have the utmost analogy of structure with the others. They are also distinguished by another circumstance; this is, that the nerves, in projecting from their textures, almost immediately form plexuses, which we have already pointed out under the appellations of cervical, brachial, lombar, and sacral, in the same manner as the soliar, cardiac, mesenteric, &c., are formed by the nerves of organic life at the moment they project from their respective ganglions; however, these last nerves are the conductors of very different properties. If in a living animal the superior cervical ganglion be irritated, or even the inferior one, which is attended with more difficulty, although it may be accomplished, the muscles which they provide with nerves will not be affected: the same phenomenon is observed when the nerves themselves are excited. On the contrary, all irritation of a filament proceeding from the vertebral ganglions, instantly produce convulsions in the corresponding muscles. Sensibility is also perfectly different in both these species of nerves. Besides the manner in which the nerves pass in every direction from the vertebral ganglions, and that in which the other ganglions furnish theirs, do not admit of any analogy. Until further experiments enlighten us in this respect, let us be satisfied in explaining what strict observation supports.

ARTICLE II.

Nerves of Organic Life.

SECTION I.

Each ganglion is, as we have observed, a centre from which various branches proceed in different directions, the whole of which form a small insulated nervous system. The manner in which these branches arise has very little resemblance to that of the cervical branches and of the spinal marrow. The following are the differences by which they are distinguished:—

1st. The adherence is much stronger; the nerve is even more easily broken in any other part than at this origin. 2dly. It does not appear that the substance of the ganglion is continued in the nerve to form its medullary substance, since the organization of both are perfectly distinct from each other. In a few instances, however, the ganglion is prolonged for a short space in the form of a cord. This occurs particularly in the superior cervical, in the lombar, in the semi-lunar, &c. —then the form only differs; but at the slightest glance it is easy to perceive where the ganglion ends and the nerve begins. 3dly. This origin is suddenly produced, it is like a muscle implanted in a tendon; the best method to ascertain this distribution, is to divide in a longitudinal direction the superior cervical ganglion and the cord it sends to the inferior one: the change of nature in both becomes then very conspicuous; or if the ganglion must be conceived as the union of numerous filaments of nervous cords, the sudden change these threads undergo in proceeding from the cord to the nerve is readily ascertained. 4thly. The dense cellular coat which envelopes the ganglion extends along the origin of the nerve, and gives it in this part an additional degree of consistence. It must be carefully removed before we can arrive at the nerve: then, every filament is distinctly seen to proceed from the ganglion. After it has passed out, it is sometimes found in an insulated state, which is the case with the semi-lunar, the lombar, and the ophthalmic, whose extensions are extremely fine. Sometimes several of these filaments unite and form a cord, of which the two cervicals, the great and small splanchnic, &c., afford us instances.

I have never been able, by boiling, maceration, or acids, to destroy the adherence of the nerve to the ganglion, in the same manner as the muscle is parted from the tendon, and this from the bone, &c.

SECTION II.

Course, Termination, Plexus.

The nerves having proceeded from the ganglions are disposed different ways, which will now be considered.

1st. There are always some that instantly proceed to the system of animal life. The ophthalmic ganglion sends branches to the common motors, and to the nasal nerves with its ramifications. The spheno-palatine sends communicating branches to the superior maxillary nerve ; the superior cervical to every surrounding nerve ; namely, above to the external motor; inwardly, to the great hypoglossal, to the par-vagum, to the glosso-pharyngeal, to the spinal, &c. ; backwards, to the first cervical pairs. All the ganglions, placed the one above the other along the vertebral column, send communicating branches to every pair from the foramena with which they correspond. The par-vagum communicates with the semi-lunar, &c. ; then there actually does not exist a single ganglion from the nerves of animal life. From thence is derived the expression habitually made use of, indicating that a ganglion proceeds from such or such a pair, or is found in their course, expressions that are very incorrect. Thus, the ophthalmic is never met with in the course of the common motor: they exchange branches which interweave, or rather there is a communicating branch existing between the ganglion and the cerebral nerve. In general, all these branches communicating with the system of animal life, are short, of a whitish hue, and of the same nature; or at least, of the same appearance as the nerves of the last system. They form no plexuses in their course, seldom shoot forth branches, and seem calculated for no other purpose than to produce anastomoses between the two systems.

2ndly. Every ganglion sends branches upwards and downwards to the ganglions that are contiguous. We have already ascertained that the ophthalmic and spheno-palatine are exceptions to this rule. Sometimes, also, as I have stated, there are interruptions in other parts. Let this be as it may, these general communications may induce us to consider ganglions as in every instance connected, and calculated to receive from each other the different affections of which they might have been originally the separate seat. These communicating branches are as straight as the preceding, sometimes very small, as those between the lombar and sacral ganglions; at other times, they are more voluminous, as that which is intermediate to the two cervical, superior, and inferior; in other instances, they are very large, as the great splanchnic, which is the real trunk of communication between the intercostal and the semi-lunar. The nerves of which we are now treating, particularly the latter, have, like the preceding ones, a disposition perfectly analogous with cerebral nerves; they are composed of whitish cords, which proceed from filaments. The eye cannot discover any distinction betwixt them.

3rdly. Several filaments proceeding from the ganglions resort to some cerebral muscles, as the diaphragm to some of those of the neck, &c.; others proceed to the adjoining organs.

4thly. The greater part projecting from the ganglions in insulated filaments, interweave in the form of a plexus with those of the neighbouring ganglions, near to, or upon the large vessels. The most remarkable of these is the solar plexus, which is formed by the innumerable branches proceeding from the semi-lunar, then the hypogastric, the cardiac, &c.; the greater part are not exclusively produced by the nerves of organic life; those of animal life assist also in their formation; the par-vagum affords an instance in respect to the solar and cardiac plexus; the nerves of the sacrum in respect to the hypogastric, &c.; however, in the plexus the nerves of organic life always predominate: it is only the pulmonic or the par-vagum that are exceptions, whilst the nerves proceeding from the inferior cervical ganglions appear to be only accessory. The primitive plexuses arising from the interweaving of the organical nerves at their exit from the ganglions exhibit a mass of irregular nerves imbedded in the cellular membrane, accommodated to the forms of the neighbouring organs, and very distinct from those of animal life, as the brachial, the lombar, &c. In fact, at every moment the filaments not only, as in these, are placed next to each other, and exchange their connections, but their extremities are also continuous; they interweave together, incessantly change their direction, form angles, forming plexus of net work, so intermixed that it is not possible to distinguish any thing more than a mass of nerves, which appear to spring up beneath the cloth that wipes the part in which the plexus is situate.

These organs are remarkable for their reddish, or greyish hue, for their softness, and particularly for their manner of being nearly concealed, &c.; it is sometimes very difficult to distinguish them from the cellular membrane. The best method to make them evident, is to open the subject, and macerate it for a day or two in water: they will then whiten sensibly, will not soften, but on the contrary, seem to acquire a tolerable degree of firmness, as those of the brain, in similar cases; besides their tenuity is such, that it is impossible to submit them to any kind of re-active; I have only observed, that they possess, in an eminent degree, the power of contracting, and do not seem in this respect inferior to the cerebral nerves. This excessive tenuity proceeds from all the filaments being insulated instead of being united into cords, as in the preceding. This is also the reason that the nerves are so numerous. If all the filaments of the brachial plexus were separated in the same manner as those of the solar plexus seem to be, they would present the same aspect, and be equally numerous.

Do the primitive plexuses formed by ganglions take an active part in nervous functions?—are they so many centres to which important phenomena must be referred? What has not been said on this subject respecting the solar plexus?—but nothing, I believe, of what has been advanced on this point, is founded upon strict observation.

The plexuses of organic life soon separate into different divisions, which proceed to various parts, particularly to those of the same life. These divisions result from innumerable filaments always found in an insulated state, although close to each other, and which, like the preceding, never unite to form a cord; they accompany almost every artery: thus the renal, the hepatick, splenic, coronary, stomachic, mesenteric, hypogastric, the carotid, and its distributions, &c. are attended with filaments proceeding from the ganglions. These filaments are disposed in two different ways. 1st. Some attend the artery without adhering to it, being separated by a great quantity of cellular tissue; they follow its course without visibly intermixing with each other. 2dly. The others form, as it were, a new tunic exterior to the former, adhering intimately, and so intermixed, that they might be mistaken for a real theca surrounding the artery.

When the artery runs but a short distance, these two orders of branches remain perfectly distinct from each other till they reach the organ, as may be seen round the splenic, the hepatick, the renal, &c.; but if its course be more extensive, the exterior branches gradually pass into the arterial plexus, where they are totally lost. This plexus may be followed on the large trunks; it divides at every branch and is still apparent; but such is its tenuity on the ramifications that it is completely lost: the spermatic is amongst those arteries in which it can be distinguished at the greatest distance. The arteries of the limbs do not appear to be provided with them: in general, it is upon the arteries which resort to the central organs of interior life that this net work is the most obvious. If we deduct from the sum total of the filaments proceeding from the ganglions, those by means of which they communicate on the one part with each other, on the other part with those which resort to the nerves of animal life, it will be found that the remainder are ultimately intended to accompany the arteries. This disposition is quite the reverse of that of the cerebral nerves, whose filaments are merely in opposition with these vessels. The adhesion here is so very strong, that they may almost be considered as forming one body, and this naturally bespeaks a use in respect to circulation and other organic functions with which we are not yet acquainted. As these vessels distribute every where the materials indispensable to these functions, of secretions, of exhalations, of nutrition, &c., organic nerves must, undoubtedly, have some influence over them. Neither experience nor observation have hitherto discovered any thing on this point.

Veins are not so plentifully surrounded with the accompanying organic nerves. It is the same with the absorbent trunks, which proceed almost every where in an insulated state from this system.

The constant union of arteries with the organic plexuses, an union which bespeaks quite an opposite disposition from that of the ganglions, must undoubtedly influence the action of the plexuses, or rather, that of the nerves proceeding from them, by the motion they receive from the blood. It is to be remarked in this respect, that in the same manner as nature has provided the basis of the brain with innumerable arteries to agitate it by an alternate motion, she has also placed the most considerable plexus of the whole organic system on such parts where the red blood imparts a stronger impulsion, namely, on the celiack trunk.

SECTION III.

Structure, Properties, &c.

FROM what has been previously stated, it is evident that the nerves which proceed from the ganglions are of two kinds, in respect to organization: 1st. Those which are identified with the cerebral system, by their whitish colour, by the possibility of separating their trunks into distinct cords, and these into filaments, which like the preceding, appear to be provided with a *nevrileme* and a medullary substance ; 2dly. Are those which seem merely composed of diminutive filaments, insulated, of a reddish or greyish appearance, of a soft nature, and found in considerable numbers in the plexuses, provided with a theca and medullary substance?—it is impossible to decide.

In organic nerves, it is difficult to ascertain the properties of the texture. In respect to the vital properties, it cannot be doubted but that animal sensibility in these nerves is not carried to such an extent as it is in those of animal life. I have frequently laid bare the abdominal plexus, then, by allowing the animal a few moments rest, and by irritating them comparatively with the lombar nerves, I have in every instance been led to this remark. We are well aware that in cases of sarcoceles, the immediate ligature of the spermatic artery is hardly attended with pain, although it is covered by branches proceeding from ganglions, with a plexus in the form of a net, and which cannot possibly be removed. If we draw out a part of the intestines through a small aperture made in the abdomen, the irritation of the sub-mucous layer on the side of the vessels is hardly felt, although that part is amply supplied with the nerves proceeding from the ganglions. I have had innumerable opportunities of acting in different ways upon the carotid artery, the upper part of which is supplied with branches from the superior cervical ganglion: but as long as I did not interfere with the par-vagum, the animal remained perfectly calm. I am far from being convinced, however, that the nerves of ganglions are absolutely devoid of sensibility; but undoubtedly under similar circumstances to those I have just mentioned, the cerebral nerves would have produced much greater pain in the animal.

I am induced to believe, that in the morbid state this sensibility is considerably increased. It cannot be denied, that the solar plexus takes an active part in the different sensations we experience in the epigastric region. It is probable, that the acute pains which generally attend the formation of aneurisms are partly owing to the distention of the nervous filaments that accompany the artery. I have already said it is highly probable that the organic nerves are materially concerned in the different sensations we experience from certain nervous affections.

In some cases these nerves give place to evident sympathies, and to this must be attributed the various injuries that Petit de Namur has produced in the organ of sight, by irritating such of its branches as are accessible to our experiments. The developement of the nerves of ganglions follow pretty nearly the same laws as those governing the organs from which they proceed.

Let us remark, in concluding this system, that there is not one in the economy more deserving of particular attention on the part of the physiologist; all the others present a series of phenomena with which we are already perfectly familiar; in this, we have hardly perceived any thing.

Hitherto, it has only presented attributes that are at variance with those found in the nervous system of animal life. Thus, it cannot be doubted, that in animal sensibility the nerves of organic life do not take such an active part as the preceding; that they are always strangers to the same kind of contractility; that they do not in a direct manner influence sensible organic contractility, since, as we shall afterwards perceive, they may be cut, divided, or irritated, without annihilating or increasing the motion of the muscles to which they resort: but, although aware of the functions they do not fulfil, we are still ignorant of those for which they are really intended. I have already mentioned, that the difficulty of making experiments upon the ganglions and plexuses will very much impede the progress of science: we have scarcely any branches externally upon which we can act.

Scarpa, in respect to the uses of ganglions, having united the opinions of his predecessors with his own, I shall refer to him on this subject; as the general point of view under which he represents these organs, and that under which I have presented them, differ essentially. The exposure I have just made of the nerves of organic life necessarily bear a general character quite distinct from that of his work; a work, however, which (like every thing that author has published,) does the greatest honor to the anatomical epoch in which we live.

I shall conclude this chapter by an important reflection. If nerves only divided in the ganglions, if these disclosed within nothing more than a division of their filaments, excessively multiplied,—why should they be so constantly met with in animals? Numerous organs are wanting, they differ, and are found in a thousand different shapes in their various classes; on the contrary, the ganglions are constant. Even in those species in which the cerebral system is imperfect, that of the ganglions, with respect to its organization, is fully developed. In the greater part of insects, in worms, &c., and generally in those animals which are not provided with vertebræ, animal life decreases and is confined in a striking manner; then the brain and its nerves become less evident in proportion as this life is less perfect. In animals, on the contrary, organic life is fully developed; the ganglions and their nerves are also very conspicuous. I have been struck with this remark, on reading the researches of various authors, respecting the anatomy of the lower classes of animals: Now, if ganglions were not the centres of certain important functions with which we are not yet acquainted, why should they be so unvariable in the animal organization?

SOCIETY

VASCULAR SYSTEM

OF

THE RED BLOOD.

ARTICLE I.

General Considerations respecting Circulation.

Since the important and celebrated discovery of Harvey, all authors have considered circulation in the same point of view; they have divided this function into two parts: the one has been called *the great circulation*, the other the *small*, or the pulmonic, the heart being intermediate to each, and their common centre. But in thus representing the course of the blood, it is difficult at first to perceive the general object of its circulation in our organs: the manner in which I describe in my lectures this important phenomenon of the living economy, appears to me better calculated to convey a full conception of it.

SECTION I.

Division of Circulation.

I DIVIDE circulation into two kinds: the one conveys the blood from the lungs to every part of the body, the other returns it to the lungs; the first is the circulation of the red blood: the second, that of the black.

Circulation of the Red Blood.

The circulation of the red blood has its origin in the capillary system of the lungs, where it assumes the peculiar character that distinguishes it from the black, in consequence of the principles which it borrows from air. From this system, it passes into the first divisions, and, subsequently, into the trunks of the pulmonary veins; these pour it into the left auricle of the heart, which transmits it to the ventricle, from whence it is propelled into the arteries and distributed through the general capillary system, which may indeed be considered the termination of its course. The red blood is then continually conveyed from the capillary system of the lungs to the capillary system in general. The cavities that contain it are all lined with one continued membrane, which membrane, being extended through the pulmonary veins in the left cavities of the heart and in the whole arterial system, may really be considered as a general and continuous canal, strengthened externally in the pulmonary veins by a loose membrane, in the heart by a fleshy covering, thin in the auricle, and compact in the ventricle, in the arterial system by a fibrous coat of a peculiar nature. In those varieties of organs that are adventitious to its structure, this membrane remains, as we shall see, almost every where the same.

Circulation of the Dark Blood.

The circulation of the dark blood takes place in an inverse manner to the preceding. It has its origin in the general capillary system; it is in this system that the blood assumes the peculiar character that distinguishes it from the preceding; and it is here that it is, as it were, regenerated, owing, probably, to the subtraction of the aerial principles it has acquired at its termination in the lungs. From this general capillary system it is received into the veins, which convey it to the right cavities of the heart, from whence it is propelled through the pulmonary artery to the capillary system of the lungs: this system is its real termination, as it is also the source from which the red blood flows; a general membrane, every where continuous, lines the whole passage of the dark blood, and affords it a general and extended canal, through which it is habitually conveyed from every part into the interior of the lungs. Nature has furnished the external part of this general canal with a loose membrane in the veins, fleshy fibres in the heart, and a peculiar fibrous texture in the pulmonary artery; but like that of the arteries, it remains nearly always uniform, notwithstanding the difference of the organs to which it is united externally. It is this general membrane which, being reflected, forms the valves in the veins; it serves to compose all those of the right side of the heart, whose cavities it lines in the same manner as the preceding in respect to the formation of the valves of the left side, which are formed by the lining membrane.

Difference of the two Circulations.

From the general idea I have just given of the two circulations, it appears that they are perfectly independent of each other, excepting at the origin and termination where the red blood and the black undergo an alternate change, communicating together for that purpose by means of the capillary vessels. Throughout the whole of their course they are perfectly distinct. Although the two portions of the heart are united in one entire organ; they may, however, be considered as constantly independent in their action; there are, in effect, two hearts, one on the right, the other on the left: both might fulfil their functions equally well if separate, as they do in their present position. Such is the disposition of the two folds by which it is separated, that even in cases in which the foramen ovale continues open after birth, the black blood cannot intermix with the red, and the two hearts ought to be equally considered as independent, at least in respect to the circulation of the blood. This complete separation of the two circulations is one of their most striking characteristics; it proves alone how much the point of view in which I have represented circulation in general is preferable to that in which it is divided in large and small, which are evidently confounded and identified with each other. From what has been stated above, both the origin and termination of the two circulations exist in two capillary systems, which are, as it were, limits between which the two kinds of blood are in motion. The lungs answer alone in this respect to different parts of the body. The capillary system it contains, is, (with a slight exception in the parts from which the blood of the vena porta proceeds,) opposed to that of all the other organs. Each capillary system is then at the same time both an origin and a termination. The pulmonary is the origin of the circulation of the red blood, and the termination of that of the black. The general capillary system affords a termination to the red blood, and an origin to the black. Let us observe, that this again, is an essential characteristic that distinguishes the two circulations. In fact, the blood not only takes a course opposite to the part where it terminates, and where it begins, but the nature of the fluid is moreover perfectly changed, and in this respect, the two capillary systems, the pulmonary, and the general one, individually display one of the most important phenomena in the living economy; namely, in the first, the change of black blood into red; in the second, that of red into black.

The general question respecting each of these circulations, evidently offers three things to our examination: 1st. The origin. 2dly. The course. 3dly. The termination of the two species of blood. In the origin and termination, we shall find, on one hand, the mechanical phenomena of circulation; on the other, the phenomena of the changes in the blood. In the passage of this fluid, we have only to observe the mechanical phenomena of circulation.

Mechanical Phenomena of the two Circulations.

In examining these phenomena in a general manner, it is perceived, 1st. That the red blood flowing from the lungs, proceeds in columns, so much the more considerable and less numerous as they approach the cavities of the heart; that in these very cavities it is found in a greater quantity, and that from these cavities to the extreme part of the vascular system, it progressively decreases by ramifying in diminutive streams; 2dly, That the dark blood flowing from the general capillary system goes on uniting into columns, which are larger and less numerous in proportion as they approach the cavities of the right side of the heart; that these cavities form that part of the great canal in which it circulates, which contains it in greater quantities, and that from these to the heart, it is divided successively into smaller columns.

The two kinds of blood then circulate in both cases in streams, so much the more minute as they are removed from the heart, and larger as they continue to approach it.

For both of these circulations, let us imagine two trees united at their trunks, and projecting their branches, the one to the lungs, the other to every part of the body. Each of the two sides of the heart is placed between these trunks, uniting them, as it were, to form the general canal of which we have spoken.

Authors have generally considered the arteries and veins as forming each, by their union, a general cone, whose basis corresponds to the extreme parts, and the apex to the heart. This method of viewing them proceeds from the circumstance of the sum total of the ramifications being more considerable in diameter than the trunks from which they proceed; but in adopting this idea, it is evident that each half of the heart is as the summit of the two cones which would otherwise be united. The pulmonary veins represent the one, the aorta the other, for the system of the red blood. In that of the dark blood the two cones are formed, on the one hand, by the venæ cavæ and the coronaries, and on the other by the pulmonary artery. In each circulation one of these cones, namely, the pulmonic, is remarkable for its shortness; the other, or the general one, for its extent.

Placed between these two cones, the sides of the heart must be considered each as an impelling agent, which forces the blood on the one hand to all the parts of the body, on the other to the lungs. In fact, if in each circulation these two cones were united at their summit, it is evident that the parieties of the vessels that compose them would be inadequate to sustain the necessary degree of motion from the basis of the one to that of the other; that is to say, from the general capillary system to that of the lungs, and reciprocally from the capillary system of the lungs to that of the other. Indeed, the course is evidently too long, and the vital powers of the vascular parieties are too inactive to produce this effect; from thence the necessity of the heart.

This consequence naturally leads to the following: As the red blood has a much longer course to traverse from the heart to the general capillary system than the dark blood has from this viscus to the capillaries of the lungs, it was necessary that the portion of this organ belonging to the former should be endowed with greater power than that intended to maintain and perpetuate motion in the latter. Nature has fulfilled this end by providing the left ventricle with a much greater number of fibres than the right. With regard to the auricles, as they are merely intended to receive the blood and transmit it to the ventricles, with which they form, in some measure, but one body, their thickness is nearly uniform.

From this we perceive, 1st, That the part which the heart enacts in both circulations, relates directly to the mechanical phenomena of the course of the blood, and that if it exert any influence over the composition of this fluid, it can only be by the internal motion that is imparted to it: 2dly. That if the course of the two circulations were less extensive, they might dispense with this intermediate impelling agent. This is precisely what takes place in the venous system of the abdomen, the two trunks of which distributing their branches, the one to the gastric viscera, the other to the liver, unite in what is termed the sinus of the vena porta, which occupies precisely the situation of the heart in the two great systems of circulation.

It is not then difficult to conceive, 1st, How the heart may be deficient, as we have some examples in which the two great circulating systems resemble to a certain extent that of the abdomen: 2dly, How the blood may still circulate for a considerable time from one capillary system to the other;—the heart, disordered, enfeebled, or even partially disorganized, has barely any longer the power of propelling this fluid: 3dly, How, although the functions of this organ, as in syncope, asphyxia, &c. be entirely suspended, there is still a circulation (oscillation), an actual progression of the blood from one capillary system to the other; since, if an artery or vein be opened, it still flows in some degree through the aperture. This circulation is certainly very feeble, and could not be carried on for a length of time; but it cannot be denied that it may take place without the intervention of the heart, since without any impelling agent the dark blood is readily conveyed from the intestines to the liver, from whence it follows that the cessation of action in the heart does not prove (as some authors have pretended) that the blood is motionless: 4thly, It is known that in several of the inferior classes of animals there is no heart, although they are provided with distinct vessels and circulating fluids.

The important part which the heart enacts in the animal economy, relates only to the impetus it communicates to all the organs, and to the habitual excitement that is maintained by this impetus. It does not convey the materials for secretion, exhalation, and nutrition; but in this respect merely transmits what it has itself received from the lungs.

SECTION II.

Reflections on the General Uses of the Circulation.

This leads us to some reflections on the general differences of the uses of both circulations, differences that fully establish the necessity of presenting the sole function that results from considering them in the point of view which I have suggested, and not in that generally used in physiological works. These differences are as follows:

General Uses of the Circulation of Red Blood.

It is the circulation of red blood that furnishes the materials of the secretions, excepting, however, the bile, a fluid that claims further examination. From this circulation the serous, cellular, cutaneous, medullary, and other exhalants, receive the fluids transmitted to their respective surfaces. All vessels that convey the principle of nutrition to the organs are also continuous with the arteries, and their fluids consequently proceed from the arteries. Even in those organs that are supplied with dark blood, as the lungs and the liver, there are vessels of dark blood obviously intended for nourishment. It is the red blood that conveys to all the organs of the body that impulse necessary to their functions, an impulse so manifest in the brain. The circulation of the red blood is then the most important; it is that from which the great phenomena of the economy are derived.

General Uses of the Circulation of the Dark Blood.

The circulation of the dark blood on the contrary, unconnected with all the functions, seems only intended to repair the losses which the blood has sustained in the preceding. Let us observe that a considerable quantity of the red blood has been expended on the exhalations, the secretions, and nutrition. The principles that it had derived from the lungs, and from which it received its brilliant colour, have been deposited in the general capillary system. It is requisite then that the dark blood should receive what the other has lost, and a variety of substances are poured into the great canal that contains it. These substances are either interior or exterior.

1st. The great trunks of the absorbents are incessantly adding the lymph of the cellular tissue, and of the serous surfaces; the residue form the nutritive matter of all the organs, the superabundant fat, sinovia and marrow. 2dly. Every thing within, that is to be rejected, is received by it. The chyle produced by digestion, is first invariably carried into the great canal, where it circulates. In the second place, with this, are mingled the atmospheric principles that traverse the lungs in the act of respiration. Finally, whenever cutaneous or mucous absorptions take place, the dark blood is always the first to receive the produce.

From thence it follows, that the circulation of the dark blood, is, if I may so express myself, a general reservoir into which every thing that is to be expelled the body, and that enters it, is first deposited.

In this respect it acts a very essential part in diseases; in fact, it cannot be doubted, 1st. That noxious substances may be introduced with the chyle into the economy, and by circulating with the fluids, produce disorders more or less sensible. To produce this effect, it suffices, that the organic sensibility of the chyliferous vessels be impaired; they will then admit what they had previously rejected, in the same way as glands, from a change of their organic sensibility, frequently secrete fluids that are not common to them. 2dly. It cannot be doubted, that besides the principles that give colour to the blood, the poison of miasma is received into the lungs and produces diseases, as my experiments on asphyxia have elsewhere proved. The intestines, the lungs, and the skin, are then a triple door open on many occasions to various morbific causes: now these causes, which thus enter the economy, are all in the first place received into the dark blood; it is only subsequently that they are received into the red.

A striking proof of this assertion is, that phenomena, perfectly analogous to those resulting from the causes already noticed, may be produced by injecting artificially into the dark blood such substances as are introduced by the natural passages. Thus, a purgative or emetic infusion thrown into the veins, &c. produces evacuations and vomiting, in the same manner as when the solid parts of these fluids are introduced through the medium of the skin by friction. The experiments of numerous physiologists leave no doubt on this subject. I am convinced that it is possible to produce artificial diseases in animals, by introducing into their circulation different substances from injecting the veins. I shall treat of these experiments in the article of the glandular system;

at present I shall satisfy myself by mentioning them, to prove that the dark blood is a general reservoir into which a variety of substances may enter, either naturally or accidentally, and subsequently disturb the functions by flowing with the circulating mass. The humoral pathology has undoubtedly been exaggerated, but it is founded on solid principles; and in many cases it cannot be doubted that all the phenomena may be referred to a vitiated state of the fluids.

From all that has hitherto been stated, we may conclude, 1st, That the essential part which the circulation of the dark blood enacts in the economy, is to impregnate that fluid with various new substances. 2dly, That on the contrary, that of the circulation of the blood is to distribute its constituent principles. The one progressively increases, the other decreases in the same proportion: to distribute is the attribute of the first, to receive is that of the second. This discovery, which is strictly supported by truth, and founded upon the simplest observation, appears to me of importance, and assists in establishing the distinction that I have adopted with respect to the general circulation.

The state of health supposes a perfect equilibrium between the abstraction of the red blood and the addition to the black. Whenever this equilibrium is destroyed the consequence is disease. If the dark blood receives more than is given off by the red, plethora supervenes. What is termed an impoverished state of the fluids, takes place when the red blood loses more of its principles than the dark blood regains.

Enough, I believe, has been said with regard to the characteristic properties of the two great divisions of the general circulation, to justify the point of view in which I have presented this important function of the animal economy, and in which I differ from other authors.

ARTICLE II.

Situation, Form, and general Distribution of the Vascular System of the Red Blood.

From the general idea that has been given of each vascular system, the following must be inferred relatively to the position of that of the red blood in the animal economy.

1st. The capillary system of the lungs gives rise to a multitude of ramifications, that unite into larger ones, then into branches, and finally into four large trunks, two for each lung; these trunks open into the left auricle towards its upper part. 2dly, This auricle being distinguished from the right by the smaller number of its fleshy columns, by its diminished capacity, by the greater length of its appendage, which is straighter than that of the other, and communicates by an oval aperture, furnished with valves, with the left auricle, which, by the thickness of its parieties, the arrangement of its fleshy column is distinguished from the right. 3dly. From this ventricle arises the aorta turning downwards, the common trunk, from which proceed all those intended to convey the red blood to every part of the body, where they communicate with the general capillary system.

The first tree of the system of red blood, the trunk of the second, and the heart that serves to unite them, are contained within the cavity of the thorax; whilst the branches of the second trunk are distributed to all the organs of the economy, and extend even to its extreme parts.

It is nearly between the upper and lower third of the body that the impelling agent or heart is situate. This position is by no means unimportant; it places under the immediate influence of this viscus the upper parts of the body, and particularly the head, in which all the organs, especially the brain, necessarily require an habitual excitement from the red blood, to maintain their function in permanent activity. Let us observe, that, in the gangrene of old people, and in all other affections proceeding from a want of that power by which the blood is propelled to every part of the body, the extremity of the foot is first affected, and it is not till afterwards that the head and hands become the seat of this disease.

In general, there are a variety of distinctions between the phenomena that occur in the upper and those in the lower parts of the body. We shall find that the capillary system of the skin is much more susceptible of being penetrated by the blood than that of the inferior parts, which is proved in asphyxia, apoplexy, submersion in the different cutaneous eruptions, and even injections, which in young subjects darken the face more than the inferior parts of the body. Now, this difference is owing evidently to the relative position of these parts with the heart.

We have no general considerations to bring forward here respecting the first tree and the impelling agent of the circulation of the red blood: in fact, those belonging to the lungs and heart will be examined in the descriptive anatomy. It is, then, the second or the arterial tree that at present more especially demands our attention. In this article, then, its origin, course, and termination, will be successively considered.

SECTION I.

Origin of the Arteries.

This article comprises the origin of the aorta in the left ventricle of the heart; of the trunks that proceed from it; then the branches, their divisions, and ramifications.

Origin of the Aorta.

Most authors have very inaccurately described the manner in which this great arterial trunk is united to the heart. It is as follows: The internal membrane of the left side of the heart, having lined its ventricle, extends to the aortic opening, is attached to it, and reflected, to form the three semi-lunar valves; and being continued within the artery, forms a lining through its whole extent. It is this internal membrane only that unites the aorta with the heart. The proper or fibrous coat is distinct from the last. Its extremity is divided into three semi-lunar projections, corresponding to each of the sigmoid valves, which they support. These projections do not extend to the fleshy fibres, a space of two or three lines intervening, which is filled up by the internal membrane only. Between these, and consequently between the valves, are perceived three small triangular spaces, which are also filled by the same membrane. In order to distinguish accurately this structure, it is necessary to dissect carefully the origin of the aorta from without, and to strip it entirely of the adipose tissue by which it is enveloped. The artery and ventricle should then be opened, and their connexion examined in a strong light;

when, after having removed the valves, we shall readily distinguish, by the transparency of the internal membrane, and the opacity of the three festoons at the commencement of the aorta, the construction I have just described. From this it follows, that if, after the artery is accurately dissected, we detach from below upwards the internal membrane that forms the great canal for the circulation of the red blood, this vessel separates entirely from the heart.

This evident separation of the aortic fibres, and those of the heart, would furnish strong grounds for supposing that they are not of the same nature, if it were not fully established by numerous other considerations.

Origin of the Trunks, Branches, and Ramifications.

The aorta, arising in the manner already mentioned from the left ventricle, almost immediately divides into two branches; an ascending one, which proceeds to the neck, head, and the superior extremities; the other, descending, which supplies the chest, pelvis, and the inferior extremities. The former, subdividing directly into four principal trunks, differs in this respect from the latter, which forms for a considerable length one continued trunk. This, having to pursue a longer course than the other, more effectually preserves, by its formation, the whole sum of motion communicated to the blood by the heart; a circumstance, however, that, in consequence of the difference of the distance, does not, as I have already stated, prevent the impetus from being more sensibly felt by the superior than by the inferior organs. At the upper part of the pelvis, the aorta divides into two secondary trunks, whose subdivisions acquire the name of branches, and are multiplied in ramifications of various sizes.

Mathematical anatomists have exaggerated the number of the arterial subdivisions. Several have attributed a hundred to a single artery. Haller reduced them to twenty, and still less. To ascertain this correctly, we must take the arteries at their origin, and follow their course under the mucous membrane—the peritoneum, for example, where they are very apparent throughout, and the subdivisions do not, as I have often convinced myself, exceed the amount stated by Haller. The inspection of a living animal, whose abdomen has been laid open, is almost the only method that can be employed with certainty for this purpose. If injections are too coarse, they do not fill all the ramifications; if too fine, they penetrate the exhalants, and impart to the whole serous surface an unnatural colour. It is scarcely possible to ascertain, by injections, the precise point of the natural circulation. To be convinced of this, we have only to inject a dog, to open the abdomen in another of the same size, and we shall always find more or less injected vessels in the one compared with those filled with blood in the other. During the time that I was occupied in demonstrating the insufficiency of either coarse or fine injections, I have frequently made this experiment, for the purpose of ascertaining the quantity of blood in a given part.

Arteries, in dividing, form with each other very different angles. Sometimes they are right angles, as in the middle intercostal; sometimes they are obtuse, which is less frequent, as in the superior intercostal; but most frequently they are acute, particularly in the extremities. The origin of the spermatic artery is the most striking example of the acute angle.

It is generally remarked, that whenever there are two divisions, one is larger than the other, and follows, more than its fellow, the direction of the original trunk; on the inside of the artery corresponding to the angles externally, a prominence is formed by the internal membrane, which breaks the column of blood, and facilitates its change of direction. The position of this projection is extremely variable, and depends upon the angle of origin. 1st. If it be a right angle, the former is disposed in a circle, and distinct in its circumference.

2dly. If it be an acute angle, as in the mesenteric artery, this projection is very remarkable between the branch that is given off and the continuation of the trunk: it forms a kind of semi-circular point, but between the trunk itself and the branch that arises from it, the union of which produces an obtuse angle, it is not well defined. The more this angle is obtuse, and the more acute consequently the opposite one, the less evident is this projection; like the other it is semi-circular, and unites with it to form a complete oblique circle; so that the position it represents is nearer to the heart than that which is represented by the other prominence.

3dly. If the angle of origin be acute, and consequently that formed by the branch with the continuation of the trunk be obtuse, the arrangement of the parts is reversed: there is then at the mouth of the artery an oblique circle, of which the most prominent half is nearer to the heart than the other.

The origin of the arterial trunks is in general pretty uniform; but that of the branches varies so much, that it is scarcely ever found alike in two subjects. Let us take for example the hypogastric. It would be impossible to form the slightest idea of its branches, if, without regarding the manner in which they are given off, we attend only to their course and distribution.

These innumerable varieties of form are remarkably characteristic of organic life, to which they belong. Their general distribution is not uniform like that of the nerves of animal life. Even those of the corresponding limbs frequently differ in their mode of origin, and in the course of their branches.

The branches, ramifications, &c. arise at very short distances from each other. There are only the carotid and the common iliac, that run to some distance without furnishing any. Those experiments also in which it is necessary to pass tubes into the arteries, to open them, &c. are almost impracticable, except with the former: the others are objectionable on account of the branches that arise from them, which prevent them from being elevated to a sufficient extent.

The origin of the arterial trunks and ramifications does not take place in a regular and progressive manner. Thus, the smaller branches, and even the ramifications, arise equally from trunks and from branches; the brachial arteries for instance, and those of the thymus gland, arise from the aorta, and yet they are not so large as the greater part of the divisions of the tibial, which is itself only a third division of the aorta.

Course of the Arteries.

The course of the arteries differs accordingly as these are trunks, branches, and their divisions, or ramusculi.

Course of the Trunks and Branches.

The trunks are the first divisions, continuous with the two great portions of the aorta, as the external and internal carotid, the subclavian, &c. above; the iliac, hypogastric, &c. below. They are generally situate in large cavities, filled with cellular substance, as the groin, arm-pit, neck, the sides of the pelvis, &c. On dividing they form branches that are received into less spaces, and which are consequently less exposed to the influence of the neighbouring organs: both have sufficient covering to protect them from external injuries; besides, the shelter which they receive from the adjacent parts, and particularly the muscles, the circulation of the blood is also accelerated by the action of these organs, whilst the motion of the arterial trunks reciprocally communicate a shock to the neighbouring organs, and even to the whole of the extremity, that assists in maintaining its vital energy. This shock, which is often difficult to be observed, is sometimes readily discovered by the slightest inspection. If we support the elbow upon a table, and hold in the hand a body of a certain length, its extremity is seen to rise and fall in some degree at each pulsation. If we cross the legs previously bent upon the thighs, a spontaneous throb is observed in that which is uppermost. To this cause may be referred the motion of the brain, that which is communicated to tumours situate in the course of a large artery, &c. &c.

The trunks and branches are accompanied by veins, and in general surrounded by a quantity of fat, a circumstance that has appeared to favour the opinion of those who considered this fluid to be exhaled from the pores of the arteries. We have already stated what should be thought of this opinion.

The direction of the trunks and branches is subject to variation. It is generally straight in the trunks, as in the carotid, the common iliac, and abdominal arteries, which renders the circulation less sensible. When these are laid bare in a living animal, no kind of locomotion is perceived, as in trunks that are distinctly curved. There are, however, some exceptions to this rule with regard to the direction of the trunks; the arch of the aorta is an instance, as well as the internal carotid, which present numerous curves, that are erroneously thought necessary for the purpose of preventing the impetus of the blood from impairing the delicate structure of the brain. This direction being more tortuous in the branches, produces the arterial locomotion that, according to many physicians, almost exclusively constitutes the pulse.

Course of the Ramifications.

Whilst the trunks occupy the large spaces that are left between several of the organs, and the branches are lodged in the smaller ones that separate two particular organs, the ramifications are situate within these very organs, without, however, entering into their immediate structure. Thus in the muscles they are placed between the fibres, in the brain between the convolutions, in the glands between the lobes that compose them, &c. These communicate an inward motion to every organ, and facilitate its function by maintaining its particular activity, as the general activity of a part is kept up by the motion of which I have spoken above. The immediate cessation of life, when the brain is no longer affected by the force of the circulation, proves the intimate connection that exists between this inward motion and its vital energy. It is also remarked, that wherever the arteries are more numerous, as in the muscles, the skin, the mucous surfaces, &c. the living principle is much more active in those organs; on the contrary, in such as are little vascular, as the tendons, cartilages, bones, and other white parts, these phenomena are less powerful and more obscure.

In the ramifications, the curvatures are much more distinct than in the branches they are made very conspicuous by injections, particularly in the brain; but as they depend principally on the cellular tissue, they disappear in part when the vessel is entirely detached. Do these curvatures moderate the rapidity of the circulation, and is this augmented by the straightness of the arteries as much as is stated by physiologists? I think that the effects of the different directions of arteries have been exaggerated. The following are the proofs:—If in a living animal the hollow organs, as the stomach, intestines, &c. be alternately exposed when distended and when empty, we shall perceive that the circulation is equally rapid in both cases, although in the former the vessels are rendered almost straight by the distention, and in the latter their curvature is considerably increased.

2dly. I opened the carotid artery of a dog, and after having examined the force of the current of the blood, the two sides of the chest were then brought into view, the lungs instantly collapsed, and the curvatures of their vessels were consequently much increased; notwithstanding this, no diminution in the force with which the blood, after having traversed the lungs, escaped from the artery, could be perceived. It was only by degrees,—and from the influence of causes, it is not my object to examine,—that it abated; 3dly. If, in any other animal, after having opened an artery, an incision be also made in the trachea, and by means of a syringe adapted to the opening, the air be suddenly withdrawn from the lungs, that organ is instantly reduced to a very small volume; the vessels must then be rendered very tortuous, and yet, I have noticed, that in this case the blood continues for a considerable lapse of time to flow with the same force from the artery as before: 4thly. After having opened the abdomen of a living animal, I have alternately folded and extended the mesentery, in which several arteries had previously been opened; no difference in respect to the current of blood was observable in either of these instances.

Let us conclude from these experiments, that the direction of arteries does not influence the course of the blood so considerably as is commonly believed, and that all the speculations of mathematical physicians, in respect to obstructed circulation proceeding from this cause, have no solid foundation. Undoubtedly, when the fore arm is strongly bent the pulse is weakened, or even stopped, and to take care that the arm be extended, is a precaution that should not be neglected in feeling the pulse of a patient; but this phenomenon does not proceed from the curve of the artery, it is caused by the fleshy parts, which by their pressure, lessen, and even obliterate its canal. This is so correct, that the different curvatures of the internal carotid are much more striking than the single one, which at this instant takes place in the brachial artery, and yet the circulation is not impeded. Besides, if one of the intercostal arteries, which is but slightly curved, be opened, the blood is not projected from it with greater force than from the radial, &c. If the whole arterial system were empty, and it were successively filled by blood projected from the heart, it would, no doubt, be retarded by striking against the incurvated vessels. On this account, arteries whose course is tortuous, are not so readily injected, and the spermatic, for instance, remains frequently empty. But in an assemblage of tubes filled with fluid the case is quite different; the shock applied to its commencement is suddenly propagated through all the cavities it contains, and not in a succession, as I shall state hereafter.

The curvatures of arteries are accommodated to the various states in which the organs may be found; they are very striking in those intended to undergo alternate dilatation or contraction; for example, in the intestines, in the lips, and in the whole face. In the fœtus, where the testis is in the pelvis, the spermatic artery is very tortuous; when this gland descends the artery unfolds, and takes the direction which it is found to possess in the adult. In the motions of the womb, of the bladder, of the pharynx, of the tongue, &c., these curves act a very important part for the safety of these organs. In fractures of the lower jaw, they prevent the laceration of the artery that passes through that bone, a laceration without these would be unavoidable: through these the arterial system is protected from injury, in the violent, and frequently unnatural motions the limbs perform.

The extensibility of the arteries would not be sufficient to allow of such motions; in fact, whenever a straight artery has been extended its diameter contracts. In accommodating themselves to the motions of parts, the circulation would be impeded, because less space would be afforded to the blood for this fluid to move in.

This explains why, on the surfaces of every part, subject to alternate distentions and contractions, the arteries being constantly tortuous, are calculated without any actual extension to be variously elongated. I have remarked, in this respect, that the locomotion in arteries, ascertained by Veitbrecht, is much more striking during the contraction of the hollow organs, or the flexion of the limbs, than during the dilatation of the one, and the extension of the other. I have repeatedly made this remark in living animals. By emptying or distending the intestines, the stomach, the bladder, &c., the pulsation of their arteries is more or less increased.

Anastomosis of the Arteries in their Courses.

Anastomosis implies the union of several branches, by which the columns of blood are formed into a single stream. There are two modes of anastomosis. Sometimes two equal trunks are united, on other occasions a large trunk is joined to a smaller branch. In the first mode there are three varieties; 1st. Two equal trunks are sometimes united in an acute angle, to form but one: it is thus, that, in the fœtus, the arterial canal and the aorta are confounded with each other, that the two vertebral arteries give rise to the basilbary, &c. &c.; 2dly. Two trunks communicate in particular parts by a transverse branch, such are the two anterior cerebrals before they immerge from between the hemispheres; 3dly. Two trunks inosculate to form a single arch, such are the mesenteric, and then the branches arise from the convex part of the arch. From this we may perceive, that of the three modes of anastomosis between branches of equal descriptions, there is one in which two columns of blood unite and take a medium course with respect to their original position; another, in which two columns, after uniting, continue in their original course; finally, a third, in which two columns proceeding in opposite directions meet at their extremities, and from which the blood afterwards issues through secondary vessels.

The second mode of anastomosis is that of the large branches with others that are smaller. Of this there are very frequent instances, particularly in the extremities; it admits of no varieties.

It is almost always in parts distant from the heart that anastomoses are met with. We hardly ever find any in the trunks that proceed from the aorta; they begin to be frequent in the branches, as in the mesenteric, the cerebral, &c. The more the ramifications subdivide, the more they are multiplied. In the ultimate ramifications they are so very numerous as to form an inextricable net-work. This position of the vessels is intended to facilitate circulation in those parts where the course of the blood is liable to be obstructed. It is on this account that, in cavities which are left sensibly affected by the motion of the neighbouring parts, anastomosis is more frequent, as in the brain, the abdomen, &c.; whilst it is less common in the muscular interstices of the limbs, &c.

The arterial system, then, cannot be compared to a tree with insulated branches, but one in which all the parts communicate with each other, and the more frequently in proportion to their distance from the trunk.

The principal object of anastomosis—that of compensating for the obstacles the blood meets with in its course—is fulfilled in numerous instances. Thus, after tying a wounded artery, or in cases of aneurism, where there is a spontaneous obliteration of one of these vessels, anastómosis between small branches, either above or below this obliteration or ligature, are seen to carry on the circulation in the part. In such cases the collateral branches frequently become considerably enlarged; but more frequently still the capillary vessels are nearly the sole agents by which the circulation of the blood is maintained.

Anastomosis then implies a vitality in arteries. It is because these vessels are not inert, but act upon their contained fluid, that the phenomena of circulation are liable to such variations, that very often, particularly through the influence of the passions, spasm of their extremities, principally of the capillaries, forces the blood to return in another direction, which is favoured by anastomosis. This reflux is moreover indispensable in cases of inflammation or various obstructions in our organs, &c. How could circulation be performed if every ramification were to proceed separately to its respective destination? Would not the slightest stoppage produce a fatal stagnation?

I have remarked, in this respect, that anastomosis affords us the first proof of a truth that we shall soon more particularly demonstrate; namely, that in the large trunks the blood is especially influenced by the heart, and in the capillary system exclusively by the vascular parieties. In fact, it is because the vitality of arteries is all with respect to the motions in the last division, that the slightest alterations they experience occasion numberless obstructions, rendering indispensable the anastomosis, which is precisely very much multiplied at the extremity of the arterial tree. On the contrary, the vitality of the trunks having hardly any influence on the circulating fluid, this is less liable to be obstructed in flowing through them: anastomosis, therefore, which is here very rare, can be more easily dispensed with.

If the slightest cause, the least irritation, were to produce spasms in the trunks, as they do in their last divisions, it would have been requisite that they should communicate together as frequently. A fleshy texture in the large arteries and vital properties, analogous to the involuntary muscles, would unavoidably have caused numerous anastomoses, because various causes influencing these kinds of muscles, they might, at every instant, increase, against the laws of nature, their contraction, reduce their channels, and limit the progression of the circulating fluids.

Forms of the Arteries in their course.

Several physicians of this age have considered each artery as forming a cone, whose basis is towards the heart, and whose summit is directed towards the extremities; but if an artery taken between the origin of two branches be examined, either when injected or divided perpendicularly when empty, or again by taking the dimensions when it is filled with blood, it is always found to be cylindrical. Undoubtedly when viewed in its whole extent it has a conical form, in consequence of the progressive diminution it undergoes by projecting branches; but even in this sense it is less of a cone than a continuation of cylinders successively added to each other, and gradually decreasing.

Viewed in a general sense, the arterial system on the contrary, as I have already stated, forms absolutely an inverted cone, that is to say, the basis is extended to all the parts, the summit to the heart; so that the diameter of the aorta is proportionally less than that of the sum total of its branches united together. This can be ascertained by comparing a trunk with two succeeding branches. These will exceed it in diameter; and the connection being invariably the same in all the subdivisions, we must conceive that the capacity of the arterial system progressively increases.

This comparison, however, between the trunks and ramifications has been exaggerated by the mathematical physiologists, who have attributed to the latter a much greater preponderance over the former than in reality exits. One cause of error on this point, may consist in having measured the arteries externally after having been injected; in fact, the dimensions of the trunks are more considerable in proportion to their parieties than those of the ramifications sepatately examined; that is to say, *ceretis paribus*, the coats of the aorta are thinner than those of the cubital artery. This is undoubtedly the reason why aneurism seldom occurs in the branches, and frequently in the trunks, particularly when these affections proceed from a local cause; for when the cause is constitutional, small arteries, especially the radials, are frequently affected, of which I have seen two instances. This observation respecting the proportions of the arterial coats, proves the impossibility of ascertaining correctly their comparative diameter, unless they are examined internally.

These affinities are also naturally very changeable, according as the vital forces, which also vary so prodigiously, increase or contract the channel of the small arteries; and in this point of view such examination is undeserving of the importance attached to it by the ancients, whose works are scattered with endless calculations on this subject.

SECTION III.

Termination of the Arteries.

After having divided and subdivided, and displayed in their course the peculiarities we have just been examining, the arteries terminate in the general capillary system. To point out where this system begins, and where arteries terminate, would be a difficult task. We might easily prove that it is there where the blood ceases to be entirely under the influence of the heart, and so circulates only by the power of the insensible organic contractility of the vascular parieties; but how is it possible to make this distinctive line sensible to the eye?

Authors, in treating upon the termination of arteries, have viewed their continuity with the excretories, the exhalants, the veins, &c.; but it is evident that the general capillary system is intermediate to the arteries and to these vessels. Thus I shall treat of their origin in mentioning this system, which is distributed in all the organs, but which, in respect to its continuity with the arteries, displays essential distinctions according to the different systems. In fact, there are systems where these vessels are distributed with profusion, and in which consequently the general capillary system contains a considerable quantity of blood: such are the glandular, the mucous, the cutaneous, the muscular, both of animal and organic life, &c.; 2dly. Other systems are but sparingly provided with arteries, as the bony, the fibrous, the serous, &c., and consequently that part of the general capillary system which belongs to them contains but little blood.

Finally, the systems of the cutis and epidermis, the cartilaginous system, &c., unprovided with arteries, contain in that division of the capillary system, seated in these parts, nothing more than white juices.

ARTICLE III.

Organization of the Vascular System of the Red Blood.

SECTION I.

Textures peculiar to that Organization.

The red blood circulates, as I have said, within a membrane, disposed as a great canal, varying in its form, extending from the capillary system of the lungs to the general one, and displaying throughout the greatest analogy. The exterior of this membrane is provided by nature with a fibrous coating for the arteries, fleshy fibres for the heart, and a peculiar membrane for the pulmonary veins. Here I only intend to speak of the arterial coating. The fibres of the heart, and the membrane of the pulmonary veins shall be examined; the first in the organic muscular system, the second in the system of the dark blood. As to the internal membrane of the arteries, which is the same in the whole system of the red blood, it shall be examined in a general point of view.

Membrane peculiar to the Arteries.

This membrane is dense light, very apparent on the large arteries, less striking in the last divisons, where it is insensibly lost. Its colour is in general, every where alike. If in living animals the ramifications have a reddish aspect, and the trunks are somewhat yellow, the difference arises solely from the transparency of the former, which suffers the blood to appear, and from the opacity of the latter. The colour of the arterial fibre is yellowish: however, in some cases, it assumes a greyish cast. I have frequently observed in arteries undergoing maceration, that after a few days it becomes visibly red, or rather assumes a rosy hue, perfectly analogous to that of cartilages in the fœtus, or to the fibro-cartilage in the adult, when they have been submitted to the same experiment. This result, however, is not so constant in respect to arteries as it is to these two systems, wherein it never fails. Sometimes the internal membrane also becomes red, but never the external or the cellular; on the contrary, the longer they remain immersed the whiter they become. When the fibrous coatings of arteries have preserved this tint for some length of time, it gradually fades away if maceration be continued. This phenomenon is frequently more evident in the ramifications than in the trunks. For instance, the arteries at the basis of the cranium very often become red in the corpse, by remaining in the fluids that moisten these parts; on opening the scull we perceive this redness, which does not proceed from stagnated blood in the arterial cavities, as may be easily ascertained.

The thickness of the membrane, peculiar to arteries, is very obvious in large trunks. It then gradually decreases, a circumstance that essentially distinguishes it from the internal membrane, which I have found nearly as thick in the tibial artery as in the aorta. It has been thought, that in several arteries, as the cerebral, the fibrous tunic was wanting. It cannot be doubted, that on the vertebral and internal carotid, it is proportionally much thinner than on trunks of an equal size, situate in the muscular interstices; but, on examining these arteries attentively, I have evidently distinguished circular fibres: whether the slightness of their parieties promote those fatal effusions so frequently ascertained in the brain, I cannot tell. Such effusions only take place in the capillaries, never in the trunks; but it is impossible to examine these capillary vessels. I have attempted, without succeeding, to find out by injections, those lacerated by apoplexy; however, this hemorrhage does not resemble that of the serous membranes: it is not a transudation through the exhalants of the ventricles; for these cavities are but very seldom their only seat: these effusions almost always take place in the very substance of the brain itself, in general nearer to the posterior than to the anterior lobe. The cerebellum is very seldom affected. When the annular protuberance becomes so small, partial effusions, separated by uninjured medullar partitions, frequently take place.

In respect to the arteries in other parts of the body, their peculiar membrane presents a tolerably regular disposition. It has, however, appeared to me rather thinner in the interior of the liver, and of the spleen, than in the intermuscular paces, and even in the muscles.

This membrane is composed of very distinct fibres, adhering together, but easily separated, disposed by layers in such a manner, that after having removed the cellular covering, these several layers are separated with the utmost facility; a circumstance that has led several authors to believe, that the principal arteries are composed of a considerable number of coverings. The fibres that compose these layers are circular, or nearly so; those most external seem to adhere to the contiguous dense cellular texture. In fact, on removing this, a more or less considerable number always adhere to it intimately. In respect to the internal membrane, it does not appear to have any attachment; it may be removed with the utmost facility, without carrying with it any arterial fibres. The manner in which these fibres adhere to the contiguous dense texture, seems to me to be very analogous with the origin of the organic muscular fibres, which in a great many parts are fixed to the sub-mucous tissue.

Whenever a ramification projects from a trunk the circular fibres give way, and form on each side half a ring, from whence there results a complete ring, encompassing the smaller ones that form the circular fibres of the rising branch. These circular fibres continue as far as the projection of the common membrane, as we see in the interior of the arterial cavity, and which we have already mentioned; so that the whole thickness of the peculiar membrane serves to support them at their origin. However, there is little continuity between the two species of fibres. Those of the branch do not proceed from those of the trunk; it is the internal membrane, as well as some fibres of communication, that unites them together. Dissections display with the greatest facility these ingrafted branches, if I may be allowed this expression, at their origin, in the ring formed by the yielding circular fibres. This is remarked at the origin of the intercostal and of the lombar arteries, in the aorta, &c. When two trunks divide in an equal proportion, as the iliacs, the last circular fibres of the primitive trunk they formed are intimately interwoven with the origin of each of the circular layers, arising on a level with the projection that divides this origin. Thus, the last rings of the aorta cannot be perfectly separated from the first of each iliac.

In arteries there are no longitudinal fibres.

What is the nature of the arterial fibre? The generality of anatomists identify it with the muscular: but however slightly these are examined, it is easy to be convinced of their difference. It is not, undoubtedly, the absence of the reddish hue that establishes this difference, since even in the human subject, in some parts that are really of a muscular nature, as the intestines, this colour is wanting. But the muscular texture is soft, loose, and can be very much extended; on the contrary, the arterial texture, hard and solid, will sooner part than yield. This may be ascertained by tying an artery strongly. The two internal coats will be divided: the cellular coat alone resists the pressure of the ligature, although it is applied to it. On opening the artery, a section corresponding to the thread is found: this division is perfectly similar to that performed by a cutting instrument.

This experiment, pointed out by Desault, I have frequently repeated, both on the corpse and on living animals: its result, which is very constant, accounts for the frequency of hemorrhage attending the operation of aneurism. There is undoubtedly no texture so fragile, if I may be allowed the expression, as the arterial, consequently none less fit to bear the ligature; why then should it be the only one that requires it? This phenomenon alone would be sufficient to distinguish the arterial texture from the muscular. In fact, the preceding experiment, performed on a part of the intestines where the fibres are disposed, as those of the arteries, will occasion a depression or a contact of these fibres, but will not divide them.

Besides, let us compare the properties of the arterial texture with the muscular; then their vital properties, by associating the chapters in which I have explained these properties; let us oppose to each their respective developements, and particularly the various morbid alterations to which both are liable, and we shall find that they have not a single point in which there is the least analogy. Aneurism of the heart, and that of the arteries, have nothing in common but the name. In the one, there is laceration of the arterial fibres and dilatation of the cellular covering; in the other, an unnatural increase, a real developement of muscular fibres, that retain both their appearance and properties.

Notwithstanding the facility with which, in cases of aneurism, the arterial fibres lacerate, they possess in the natural state a very considerable degree of strength, and are capable of affording great resistance: another characteristic of fleshy texture.

The following lines prove this resistance both in the transverse and in the longitudinal sense. 1st. When a ligature has been applied on the upper part of the carotid artery, and a fluid is then injected, it requires a considerable degree of strength to break the texture. The very same thing is observed when the artery is inflated instead of injected. Very frequently the efforts of one man are insufficient to cause laceration: thus, the force of the heart can never occasion it suddenly; so that the formation of aneurism only takes place by gradual and long continued action on the arterial coats; even then I doubt if these tumours could be produced solely by the impulse of the circulating fluid against the feeble parieties of the arteries without a previous change in the arterial texture. 2dly. The resistance of these coats is also ascertained to exist in a longitudinal direction. If the two ends of an artery and of a muscle be drawn in opposite directions, the first will part with more difficulty than the second, when the dead body is the subject of this comparative experiment. But in the living subject it is quite the reverse, the vessel will give way to any very considerable power: to divide the muscle would require an exertion incomparably greater. This difference is derived from the vital properties of the latter, which then violently contracts, whilst the artery can only oppose the nature of its texture. However this longitudinal resistance to distention is less than the lateral one opposed to injection; experiments prove it, and the cause undoubtedly is, that in the first instance no fibres are directly opposed to the impression.

This resistance of the arterial texture differing so much from that of the veinous, is a necessary consequence of the heart being situate at the origin of the arteries. In fact, this organ, propelling forcibly the blood into their canals, requires in these a degree of strength calculated to resist the violent effort of which it is capable, whenever its sensible organic contractility is exalted to a high degree. This is the essential advantage of the arterial texture. What would become of circulation, and of every function depending thereon, if the slightest cause that might encrease the exertion of the blood could dilate their coats beyond the natural limits? It was indispensable that their texture should in some measure make them independent of the various degrees of motion of their contained circulating fluid; from whence it ensues that a fleshy heart and resisting arteries are necessarily connected. Had nature doubled the energy of the heart, she would also have proportionally increased the arterial resistance. Arteries, on the contrary, would have possessed little resistance, had they not been provided with an impulsive agent at their origin. This is precisely the case with the hepatic part of the veina porta, which, in its distribution, is analogous to arteries. Why is the pulmonary artery thinner and less resistant than the aorta? Because less fleshy, the left ventricle is only calculated for less violent exertions.

From what has just been stated, it appears that the external arterial membrane approaches the fibrous organs, which, as we shall perceive, are characterized by an excessive resistance. But if we consider that this membrane can be lacerated into parts, removed in layers and scales, that in dissection it is elastic and even dry, if I may be allowed the expression, whilst in fibrous organs all is intimately attached, forming a solid body, resistant but softer, and less capable of contraction, we shall then be convinced that this external membrane is exclusively peculiar to the arteries; that it is unconnected with the other systems, and forms in the economy a distinct and insulated texture. The texture formed of regular fibres, is, in my opinion, the only circumstance that could induce us to believe in the muscular nature of the arteries; but ligaments are equally fibrous, so are tendons: what have forms to do with intimate nature? Can we then say that the nature is the same when the physical properties, the extensibility and contractility of the texture, the vital sensibility and contractility differ so essentially?

Besides, the action of the various re-active agents on the arterial texture evidently prove how very much it differs from the muscular. There are then some general phenomena applicable to all the solids; but particular phenomena are very distinct. This fact may be ascertained by comparing the following chapter with that corresponding to it in the muscular system.

Action of the different Agents on the Arterial Texture.

That of air, by drying the arteries, gives these vessels a reddish yellow hue, rather deep, even blackish in large trunks, lighter in the smaller ones. Thus dried, the arteries are nearly as firm as cartilages in the same state; extremely brittle, the large trunks break with a perceptible noise, of which no other texture in the animal economy affords an instance. It is, particularly by this process, that the cellular texture of arteries differs from their proper membrane. This coating remains slack; it is of a whitish aspect when removed separately. When again immersed in water the arteries re-assume, in part, their natural disposition.

By desiccation, arteries do not lose much of their bulk, a phenomenon that distinguishes them from the greater part of the other textures. This depends upon the scarcity of fluid contained between its laminæ, a circumstance that seems itself to proceed from the total absence of cellular texture. The kind of dryness ascertained on opening the arterial laminæ is remarkably striking when compared to the moisture in which the muscular fibres are imbedded.

When exposed to the action of air, in a moist state, and with other organs, arteries putrefy with difficulty. Their texture seems in this respect to claim some analogy with that of cartilage, of the fibro-cartilage, &c.; for a considerable space of time, like these, it is almost incorruptible; when undergoing this process alone, the odour it exhales is much less offensive than that of the other textures. Ammonia is given out in smaller quantity. The absence of smell is also very striking in the water, in which arteries perfectly divested of any contiguous texture have undergone maceration. By comparing this water with that in which muscles have been macerated, the difference is striking. An evident proof of the resistance arteries oppose to putrefaction and maceration, is, what may be observed in the viscera that have macerated for a length of time, or undergone dissolution, as the liver, the spleen, the loins, &c. In either of these cases, particularly in the first, these organs are reduced to a state of putrescence; but in the general dissolution, their arteries have preserved their texture, which is still very resistant. By removing carefully the putrid substances, they may be traced even to their very last ramifications. This mode of examining arteries, either filled by injections, or when empty, is not difficult. In the living subject, these vessels resist putrefaction much longer than the skin, the cellular texture, &c. An artery is often seen to traverse a putrefied part without experiencing the least injury. Frequent instances of this are seen in gun-shot wounds.

After a lapse of time, which varies considerably according to the degree of temperature, the arterial texture ultimately yields to maceration and putrefaction. In the first instance, it softens by degrees, without any alteration of colour; its fibres cease to adhere; and finally, it is changed into a pulp, which is of a greyish colour, and nearly homogeneous. In the second case, it first acquires a greyish hue, is then also converted into a pulp, and when the whole fluid part has evaporated, leaves a residue perfectly different from that produced by the putrefaction of muscles. In general, the arterial texture requires a much longer time to be reduced by maceration than by putrefaction. This proves the superiority of the action of air over that of water, in the production of this phenomenon.

When submitted to the contact of caloric, the arterial texture becomes crisped, contracted, and shrunk to the last degree. Whenever the action of water is combined with that of caloric, which takes place in boiling, the following is the result: 1st. Very little scum rises before ebullition from the vessel; one might be led to believe, that in this respect the arterial texture and the muscular display two opposite phenomena in the economy; the small quantity of scum produced by the first is greyish: 2dly. At the time of ebullition, an evident shrinking takes place, less, however, than that of the nervous texture, but more characteristic in the diameter than in the axis. This is accompanied by a proportionate induration, and the water assumes a yellowish hue; 3dly. Permanency of this state for half an hour and longer, ebullition still continued; 4thly. Gradual softening; but at the same time a greyish hue succeeds to the yellowish; a deficiency of adherence in the fibres gradually encreasing as ebullition is carried on, and causing them to lacerate with the utmost facility; 5thly. For whatever length of time ebullition be continued, the arterial texture is never reduced to a gelatinous yellowish pulp, like that of the fibres, cartilages, &c. The fibres remain as they were, similarly connected, and of the same volume, &c. The deficiency of adherence and change of hue are almost the only phenomena they display; 6thly. The solution produced by boiling is insipid, and even flat: a proof that the arterial texture hardly contains any neutral salts.

By the action of concentrated acids, this texture contracts, softens, and is finally reduced to the form of a pulp, yellowish when nitric acid is the agent, black when it is the sulphuric. The effect of the greater part of the other acids is less powerful than that of these two. When they are diluted, contraction is not produced at the moment an artery is immersed, but the texture softens by degrees, and like that which has been boiled, tears by the slightest effort. For whatever length of time it is retained in the acid, it can never be reduced to a fluid state.

Alkalies, even the caustic, have scarcely any influence on the arterial texture. After a long continued maceration in these fluids it remains nearly unchanged, is but very little reduced by its dissolution, and does not lacerate in the same manner as after having been kept in diluted acids.

Common Membrane of the System of Red Blood.

By this I mean the membrane that lines the arteries, the left part of the heart, and the pulmonary veins. It is easily dissected in these two last organs. To separate it completely in the arteries, requires that a superficial incision be made round the external fibrous part, this should then be reversed layer by layer from below upwards. By these means we arrive at the internal membrane, which adheres very slightly to the preceding, and can be removed in the form of a tube of some considerable extent. It is distinguished, 1st. By its excessive tenuity and the consequent transparency. 2dly. By its whitish appearance, for it only appeared yellow from being applied over the preceding. 3dly. By the total absence of fibres. It is smooth, and like the serous membranes, has an uniform texture, which may be ascertained by examining it against the light. It differs essentially from these membranes in the kind of brittleness by which it is characterized, breaking and lacerating at the least attempt. All the resistance of which arteries are possessed resides in their fibrous tunic.

It appears that this membrane, although every where continued, affords, however, in the various regions, some differences of structure. 1st. It is evidently thinner in the interior of the left ventricle, than in the corresponding auricle and in the arteries. 2dly. In the heart and in the pulmonary veins, it admits of much greater dilatation than that of which it is susceptible in the arteries, where this, as well as the proper membrane, would inevitably be ruptured if the blood could be determined to them in such great differences of volume as to these organs. 3dly. When the heart has been macerated for a certain time, this internal membrane in the auricle and mitral valves acquires a very remarkable whitish hue, which is never observed in the remainder of its course. 4thly. In respect to the action of the different agents, as air, water, caloric, &c. it seems to be every where the same, and perfectly similar to that effected on the proper membrane, with this distinction only: in small arteries it has seemed to me that the common membrane is more liable to shrink, which, on this account, wrinkles in different parts within when a whole ramification is plunged in boiling water, a phenomenon that does not occur in large trunks.

From this, it is evident that the common membrane in the system of red blood, although not every where continuous, is not of an uniform structure. We shall have occasion to make a similar observation in respect to the two general mucous surfaces.

In the corpse, the internal surface of this membrane is moistened by an unctuous fluid, met with in more or less considerable quantity. Does this fluid exist in the living subject?—is it intended to secure the arterial canal from the impression of the blood? it is difficult to determine: no organ fit to produce it has been investigated; it might be attributed to the exhalants, as several authors have admitted it really exists. It might, however, be the case, that this fluid is merely a transudation after death, similar to that of the bile through the vesicle, or the result of some serous fluid remaining in the arteries after the blood has been expelled.

What leads me to suspect this, is, that these very arteries, when deprived of blood, admit of very intimate adhesions of their internal surfaces, which their fluid should prevent, as that in the mucous tubes, which having ceased to transmit their respective matters, the excretions, for instance, secreted fluids, &c. are never on account of this fluid found obliterated.

Then, it seems that it is the very membrane itself, and not a fluid proceeding from it, that is intended to secure the artery; in respect to the blood it can only be considered in this point of view as a kind of epidermis. It is this which, by its folds, contributes to form the aorta, the mitral valves, and also the different projections at the origin of branches and ramifications.

The external surface being, as we have seen, slightly united with the other membrane, has no intermediate cellular coat. Notwithstanding this slightness of adherence, no means whatever, either boiling water, maceration, or putrefaction, &c. will ever produce a separation of these two membranes, as with the periosteum and the bone, although naturally more firmly united together. The aid of dissection is always required. Respecting the nature of this common membrane I am perfectly ignorant, although differing in appearance it has in regard to properties the utmost analogy with the preceding envelopement. Neither of them can be arranged in any system; they form a separate texture in the economy, a texture exclusively possessed of distinctive characters.

When the common membrane of arteries undergoes dessication separately, it is much more supple than the other. Instead of acquiring the deep hue of this last, it retains its transparency. In respect to the phenomena of the other re-actives, excepting the contraction, they are nearly the same.

Amongst all organic systems, this membrane is particularly remarkable for its singular tendency to ossify in old age. I can affirm that out of ten subjects, seven, at least, after the age of sixty, will present instances of such incrustation. These incrustations, which are never connected with the peculiar fibrous membrane, always commence on its external surface, which is the part principally affected, for there always remains on the incrustation a kind of slight pellicle, that separates it from the blood, and which belongs to the membrane; the calcareous substance is never found in contact with the circulating fluid.

Such incrustations in no respect follow the common rules of ossification. They are very seldom preceded by the formation of cartilage. The saline substance is instantly deposited on the external part of the common membrane by means of the exhalants. It is always by insulated layers, more or less extensive, that this exhalation is performed; the whole of the artery seldom forms a continued solid tube, so that the membranous parts remaining between them may be considered as fulfilling the office of articular bands, and that arteries thus ossified, are composed of numerous pieces, moveable the one over the other, and enabled, in some degree, to aid the circulating motion.

As long as these layers remain thin, the interior of the artery is, as usual, even and smooth; but if some considerable quantity of the saline substance has been deposited, they then become thicker, and project inwardly. The thin pellicle that covers them, and which is continued on the artery, breaks on a level with their circumference, and then they adhere only by their external surface to the proper membrane. Their circumference, on this account, is rough and uneven. If there are a great number on the artery, the whole internal surface exhibits a thousand asperities, produced by the laceration of this excessively thin pellicle of the common membrane that covers the ossified layers. This disposition is particularly remarkable at the origin, and even in the course of the aorta. I have frequently seen it in our dissecting rooms. Since practising in the hospitals, I have already dissected three or four subjects similarly affected, and who, although the heart was perfectly sound, had died, however, with the greater part of the symptoms that characterize the diseases of that organ. The laceration of the thin pellicle that secures the ossified layers, when increased, arises from the excessive brittleness that we have observed in the common membrane, from which it depends. I have never found these bony layers completely loose, and left free in the artery.

Every part of the arterial system is liable to ossification; it is as frequently met with in the branches as in the trunks: we are sensible how very often in feeling the pulse of an aged subject we find the radial artery ossified. Ramifications appear to be less frequently the seat of such incrustations, and they never take place in the capillary system; a circumstance that rather induces me to believe that the common membrane of the arteries does not extend so far as that system, but gradually degenerates into a different texture.

It is not in the common membrane of the arteries only, that this saline substance is deposited. This frequently occurs in the very heart itself, particularly in the aortic and mitral valves. It is not so common in the internal surfaces of the left ventricle and auricle; in the pulmonary veins, however, I have some instances of it. This general tendency for ossification in its whole course sufficiently proves that its nature is every where similar, and that, notwithstanding the distinctions pointed out, I was perfectly correct in viewing it in an uniform light, from the capillary system of the lungs, to that of the whole body; for as I have already had an opportunity of observing, identity of affections implies indentity of nature. It is the frequent ossification of this membrane in the heart of the elderly subject, that renders the intermittent pulse, so common at that age. The ossification of the origin of the aorta influences also the circulation, which I have had frequent opportunities to ascertain, but those of the trunks, ramifications, &c. do not occasion the least disturbance.

The ossification of the common membrane in the system of red blood differs essentially from those formed in other parts, as in this; it is in some measure a natural phenomenon, whilst in the others, it is accidental, and frequently preceded by obstruction and inflammation. Thus, such ossifications never follow the progress of age; they are as frequent in the youth and the adult as in old persons. Before this last stage of life, the ossification of the membrane may be discovered, but not so frequently as at that period. The diseases of the heart, attended with and frequently consisting solely of the ossification of the mitral valves, are remarkable proofs of this. I have frequently been struck with a phenomenon in this respect: such ossification, as in the elderly subject, does not endanger life, but only occasions an intermittent pulse in the adult, is attended with the most fatal consequences. I have already opened several subjects, affected with great difficulty of respiration, frequent suffocation, cough, irregularity of the pulse, the necessity of a constant vertical position of the trunk, and in the last moments, with infiltration and serous effusions of the thorax, expectoration of blood, &c. and in which I found nothing more than the ossification of the mitral valves, less considerable than the bodies of aged subjects, daily present in our dissecting rooms.

I must even acknowledge, that this natural tendency in old age of the common membrane of the veinous system to ossify, had led me to believe that we have somewhat exaggerated the cases in which this ossification in the adult, and even in elderly subjects, when existing in these to a great degree, is considered as the cause of the whole series of phenomena, whose assemblage, according to the greater part of physicians, constitutes asthma. But the practice of the Hotel Dieu, convinces me every day, that those cases of ossification, of aneurism, and of all other affections that have their seat in the heart, form a class of disorders nearly as numerous as that of the chronic diseases of the lungs, to which before Corvisart, every symptom of disease in the chest was generally attributed.

SECTION II.

Parts common to the Organization of the Vascular System of the Red Blood.

Blood Vessels.

THE parieties of the arteries contain secondary arteries, intended for their nutrition. These vessels generally proceed from the neighbouring ramifications, sometimes from the very artery itself, whose capillary divisions terminate in the texture of its coat. This is demonstrated in the heart; at its exit the aorta furnishes the coronaries that plunge in the texture of that organ, and extend on the origin of that artery itself. The bronchial arteries supply the parieties of the pulmonary veins. In the arterial texture, where the minute arteries should be particularly examined, they first wind in the external cellular texture of the artery, ramifying together in a thousand different directions, sending some divisions to the adjoining organs, and a considerable number that plunge into the proper membrane, interweaving between its lamellæ, to which it distributes some twigs, and finally, terminating before they reach the internal membrane. I have never found, either by injections, nor by opening an artery in a living animal, after having previously intercepted the course of the blood above and below, such as the carotid for instance, I have never, I say, found the diminutive arteries to penetrate as deep as the internal membrane. To distinguish correctly the vessels of arteries, without the help of injections, it is requisite on one hand, to choose a large trunk, as the aorta, on the other hand, to take that trunk in a young animal, killed for the purpose by strangulation; all the diminutive arteries are then strongly injected with a very dark-coloured blood. If we examine the arteries of the fœtus, particularly if at the event of birth death has been caused by asphyxia, we shall be amazed at the great quantity of blood vessels its arteries (which are sometimes livid with them) contain.

The veins accompany every part of the minute arteries in the walls of the arterial trunks; they have nearly the same distribution. I have never seen them become so completely varicous in the parieties of arteries affected with aneurism, as in the tumours of numerous other textures in the animal economy.

Cellular Texture.

The arteries are outwardly provided with two kinds of cellular texture, that which is external is loose, impregnated with fat, filled with a serous fluid, and composed of distinct layers, unites them to the adjoining parts, facilitates their motions, and is not at all distinct from the remainder of the cellular system; the other, dense, tight, deprived of fat, is composed of filaments, instead of layers, and forms their first tunic. We have mentioned, in speaking of the cellular system, that particular layer, which incloses the arteries, commonly called by authors cellular tunic, by the ancients nervous, on account of its whitish aspect, and which is perfectly analogous to the submucous, sub-excretory, cellular texture, &c. differs essentially from the preceding, as well as from that which is in the interior, around the organs, or in their interstices.

It is these two kinds of cellular texture, particularly the latter, that especially concur in maintaining the folds of the arteries: thus, it happens, that whenever the proper tunic has been accurately dissected, these folds completely disappear. However, when on the one part they are strongly depicted, and on the other they are not frequently liable to disappear, to accommodate the extensions of the parts, as in the canal of the internal carotid, I have noticed that the arterial fibres are adapted to these folds, that they are more numerous on the convex than on the opposite side, so that, the thickness of the artery is every where exactly the same, which would not be the case were it not for this disposition, because more being pressed to the concave side, the artery on this account would necessarily be thicker in that part.

The cellular texture forms the first membrane of arteries, and furnishes, as we have seen, points of insertion for the arterial fibres, but does not plunge in the interstices of these fibres; it is this very circumstance that essentially distinguishes the layers of the arterial texture from those of the muscular and veinous systems. Whatever means I have made use of to ascertain the existence of cellular texture in those parts, I could never succeed in making it obvious. Maceration, so frequently mentioned by Haller, proves nothing of the kind. Whenever arteries, after a very considerable space of time, have finally given way to maceration, they afford nothing more than a kind of pulp that has nothing of the cellular appearance.

The re-solution of organs into cellular texture by maceration, displays a less striking phenomenon than is commonly conceived. It is this same organic texture that forms the kind of pulp that is produced. As this texture varies in every system, so does the pulp of those systems that have been submitted to maceration for a long space of time, equally vary, which undoubtedly would not be the case, if, as Haller has stated, the cellular texture were the only basis to which every organ is referred by maceration. But let us return to the arteries. The fibres of these are not composed of cellular texture, nor, as I have previously mentioned, do they even contain any in their interstices, a distinctive character of all other systems. It cannot be discovered by the most minute dissection. Whenever the fibres are separated from each other, we observe they are only in juxta-position, or united together by diminutive elongations of the same nature. I have also related, although Haller has affirmed the contrary, that the absence of cellular texture is likewise ascertained between the proper membrane and that which is common to the arteries.

I believe that this deficiency of cellular texture essentially contributes to the kind of brittleness that so particularly distinguishes the arterial texture, and which, as I have observed, renders it amongst all animal textures the most unfit to resist the force of the ligature without breaking. To this circumstance must also be referred the difficulty, nay, even the impossibility of arterial dilatations, of formation of cysts by the arterial walls. Real aneurisms, as we are well aware, never exist. Whatever may be the size of these tumours, the two membranes of the artery give way, and the cellular tunic only is dilated. From thence the necessity of the peculiar structure that distinguishes the cellular texture situate round the arteries, and gives to it a degree of resistance which in most parts it does not possess. Authors have been amazed at those ruptures that distinguish the dilatations of arteries from those of every other system. Had they only compared the texture of the arteries with that of the other systems, they would have discovered the reason of this difference.

From what has been previously stated, we may easily conceive why there is never any fat in the arterial texture; why in dropsical cases it is never infiltrated; why again no hydatids or cysts are found in its laminæ; why the various tumors which, as we have seen, are seated in the cellular texture, never interfere with arteries, &c. Whenever an artery has been wounded, either in the longitudinal or transverse direction, no granulations are seen to arise on the borders of the divided part; none, I believe, have been noticed by surgeons in the operation of aneurism. In the frequent opportunities I have had in animal subjects of cutting arteries, and then leaving them free after having intercepted the course of the blood, I have never observed any thing similar. If an arterial trunk has been laid bare, the cellular tunic frequently furnishes granulations, but they have never been observed when the precaution of removing this tunic has been properly attended to.

Exhalants and Absorbents.

Are arteries provided with exhalant vessels ?—The circumstance of nutrition, without doubt, implies their existence ; but, as I have before stated, it is not probable that any open on their internal surface.

In respect to absorbents, I once thought that the deficiency of blood in arteries, after death, proceeded from their lymphatic vessels, which still retaining for some time the power of absorption, removed the serum, that is, separated it from the coagulated part ; but later experiments have undeceived me. I have secured blood, water, the fluid of dropsical subjects, &c. between two ligatures, applied above and below, on the common carotid, which had been separated in such a manner as not to injure the vessels that might join it, but after a sufficient interval have never found any diminution in the fluid, absorption, consequently, had not taken place. I must observe, in this respect, that the carotid, being unprovided with collaterals, is, on this account, the vessel best calculated for such experiments and for numerous others analogous to these.

We are aware that the absorbents abound in such parts as are best supplied with the cellular texture, and that in general there are none in parts where this membrane is wanting. It is then probable that the absence of this texture implies that of the absorbents.

Nerves.

1st. The first tree of the system of red blood receives the cerebral nerves almost exclusively. In fact, we are aware that the par-vagum extends over all the pulmonary veins, as well as over the vessels adjoining to the lungs, which hardly receive any from the inferior cervical ganglion. 2dly. The central part of this system, that where the heart is situate, borrows its nerves nearly as much, nay, even more, from the ganglions, than from the brain. 3dly. The large tree of the red, or the arterial circulation, is almost exclusively embraced by the first class of nerves. We have already noticed how these nerves, in this respect, are distributed. The cerebral, by which they are accompanied, scarcely provide the arteries with filaments; they are merely in apposition, as is ascertained in the limbs, in the intercostal spaces, &c.

I cannot repeat too often, that the constant connexion between the arteries and the nervous system of the ganglions deserves the attention of physiologists, because it is too general not to be connected with some important object in the functions of the economy, although this is still unknown.

ARTICLE IV.

Properties of the Vascular System of the Red Blood.

Whatever we may have to advance in respect to these properties, as well as what we have stated respecting the organization, refers particularly to arteries. In fact, the fleshy walls of the heart, the membranous parieties of the pulmonary veins, are possessed of properties that will be afterwards considered, and which vary from those of the arteries, on account of the difference of texture. With regard to those of the common membrane, they are nearly the same throughout the whole course of the red circulation, organization differing only in a slight degree.

I shall consider the properties of arteries in the arterial texture and in the common membrane only; because the cellular tunic, belonging to the system of that denomination, partakes of all its properties.

SECTION I.

Physical Properties.

Elasticity, obscure in the greatest part of the other animal textures which are characterized by excessive softness, is very remarkable in arteries; it is this by which they are especially distinguished from veins. This elasticity keeps their coats distended, although they are void of blood. They are the only tubes, together with those composed of cartilage, as the trachea, the auditory passage of the fœtus, &c. which are also endowed with elasticity, that keep open of themselves. All the others collapse whenever they are not distended by the fluids that pass through them.

To the elasticity of the arterial parieties must be attributed the sudden return to their natural state, whenever their cavities have been obliterated by pressure, the instantaneous longitudinal direction assumed by an arterial tube that has been curved, &c.

This property also takes an essential part in the kind of locomotion which arteries undergo at the approach of the blood. In fact, if a curved arterial trunk be laid bare in a living animal, we shall perceive it to rise entirely at every pulsation, to relinquish its station and to straighten, particularly in the parts that are bent. At the moment injections penetrate into a small and lean subject, a locomotion of all the winding arterial branches of the face is very distinctly ascertained through the integuments. Now it is evident, that if arteries were not composed of a firm and elastic membrane, they could not thus sustain the motion to which they are subjected; besides, let us observe what happens on injecting the abdominal branches of the vena porta, which, being destitute of valves, can be injected as the arteries. On propelling the fluid, nothing like the locomotion I have just mentioned is ever seen to take place. I have frequently caused arterial blood to circulate in veins by the means of curved tubes adapted to the vessels of a living animal; for instance, by establishing a communication between the carotid artery and the external jugular vein. In veins circulating arterial blood, a kind of pulsation answering to the beating of the heart, or a sensible vibration, may be observed, but there is no real locomotion.

The locomotion of arteries implies three things: 1st. An impulsive agent that impresses a motion more or less considerable to their contained circulating fluid. 2dly. A disposition to bend, that enables the blood to straighten them by striking against their parieties. 3dly. The firmness and elasticity of these coats facilitating this direction. On the other hand, these should not be too firm. Thus, the cartilaginous texture would not be calculated for such locomotion.

The elasticity of arteries is as striking after death as during life; it is very essential to distinguish it properly from the contractility of the texture. There are numerous points of distinction; the following are the most essential:—1st. The contractility of the texture can only be performed by the deficiency of extension in the arterial coats, that is to say, because these vessels contain no longer the blood that prevents their contracting, or because they have been cut, and afterwards left to themselves. Elasticity on the contrary, in order to act, requires a preliminary compression, and manifests itself by an abrupt return of the parts to their natural state. 2dly. The contractility of the texture is in permanent readiness for contraction; it might be said that all the parts possessed of this property are in a forced state, so that whenever this ceases to exist, contraction instantly follows. Elasticity, on the contrary, is not found in that permanent readiness to be produced. 3dly. All elastic motions are abrupt and sudden, ceasing as quickly as they are produced. On the contrary, all the movements of contraction in the texture are insensibly and gradually brought on, frequently requiring several hours, nay, several days, to be produced, as may be seen in the contraction of amputated muscles, &c. 4thly. Every organ whose texture is capable of contraction, necessarily possesses extensibility: this last property, on the contrary, is not necessarily associated with elasticity, as may be observed in coarse bodies, in the cartilages of animals, &c. 5thly. Elasticity is a property solely physical, the contractility of the texture, without being vital, is proper to the organs of the animal creation only.

SECTION II.

Properties of the Texture.—Extensibility.

The extensibility of the arteries may be viewed in two respects. 1st. Transversely. 2dly. Longitudinally.

Arteries in their diameter, have only a very limited extensibility. 1st. Whatever attempts are made to dilate them by injections of water, of greasy substances, by inflating them, &c., their natural diameter is very little increased. 2dly. I have mentioned that their texture is remarkable for a kind of brittleness, and that in cases of aneurism, when somewhat distended with blood, they will sooner break than yield, and that the cellular tunic only, which, on account of the degree of extensibility it possesses and derives from the system, of which it is a part, is adapted to form cysts, in which the blood is contained. It is even this that essentially distinguishes aneurismal tumours from varices. 3dly. When a ligature has been applied to the superior part of the carotid artery of a dog, the blood forcibly pressed against this ligature that stops its course re-acts violently against the coats of the vessel, and yet this dilatation is hardly perceptible. We must not, however, conclude from this, that arteries are not calculated to yield at all; when the cause of dilatation acts gradually, it will produce its effect to a limited degree, after which the part ruptures. The proof of this exists in the frequent dilatations at the arch of the aorta, in those which take place in the first stages of aneurisms, &c.

In the longitudinal direction, arteries admit of more considerable distensions than in the preceding; we might be convinced of this on drawing out these vessels to apply the ligature in an amputated stump. On cutting, in the dead body, a part of an artery, and drawing it in a contrary direction, it becomes evidently elongated. In performing these experiments, the developement of the curves should not be overlooked. In fact, I have said that this acted the principal part in the extension of the arteries situate in parts that undergo dilatation.

It is evident that the extension operates transversely, it is the circular fibres of the peculiar membrane that afford the chief resistance; on the contrary, in the opposite sense, it is the common membrane that opposes the resistance, since these are not longitudinal fibres. This clearly explains why the first mode of extensibility is less striking than the second.

Contractility.

This must also be considered in the opposite significations.

Examined in the first point of view, contractility is much more striking than extensibility. Whenever the artery ceases to be distended by the blood, it evidently contracts. To this contraction, the following phenomena must be referred. 1st. The umbilical artery and the arterial canal become, after birth, by the adherence of their walls that have contracted, a kind of ligaments. 2dly. If a ligature be applied to an artery, the whole part included between this ligature and the first collateral branch soon displays the same phenomenon, which is proved by the operation of aneurism. 3dly. If a part of the carotid be included between two ligatures, and the fluid be then drawn by a puncture, it will instantly be reduced to half its diameter. 4thly. In dogs, into which I had transfused blood to produce artificial plethor, I have observed, that the diameter of the arteries was nearly double that which these vessels presented in dogs of the same size, and which I had bled profusely. If two animals of the same size be killed, the one by bleeding, the other by strangulation, they will afford the same distinction. 5thly. These experiments no longer permit me to doubt, in respect to one of the causes for an elevated or a reduced pulse, causes that are also admitted by most physiologists. 6thly. However few may be the bodies we have opened, we must undoubtedly have been astonished to find, that in those of a similar stature the arteries have different diameters; this depends solely upon the moment of death. If, for want of blood, the arteries have remained for some time contracted, they continue in that state, as may be seen in the heart when death is occasioned by hemorrhage. This is so true, that arteries of different diameters usually become equal by injection, which produces an uniform degree of extension they cannot exceed. 7thly. In the longitudinal wounds of arteries, the ends of their divided circular fibres retract, by which a space, that always continues, is left between them.

The greater part of authors have confounded the contractility of the arterial texture with irritability. It is not requisite to point out here how much they have been deceived.

Not one of the preceding cases requires that a stimulant should be applied to the arterial texture; the only indispensable condition, is the want of extension, a distinctive characteristic of the contractibility of the texture; besides, it is evident that this property is manifested after death, although less sensibly than during life; whilst a few hours after life has ceased, all kind of irritability has completely disappeared. I believe it is especially in the arterial system that the advantage to be derived from my division of the properties of our organs may be seen. If we read all the authors on this system, we shall find that they do not understand each other, because they have not assigned the limits of vital properties, and of texture.

The contractility of the texture in the longitudinal direction is proportionally less striking than in the other; however, it does exist. 1st. Thus it happens, that when an artery is divided between two ligatures, the two ends instantly contract in opposite directions. 2ndly. This retraction is evident in amputation; however, as that of the skin, and of muscles, is more considerable, the artery often projects a little. 3dly. If cut transversely in a portion of its coats, an artery will frequently present in that part a wide opening, depending upon the retraction of the divided parts, similar to that of the longitudinal wound I have just mentioned. 4thly. It is particularly at a time when an artery has been strongly drawn, and suddenly let loose, that its re-action is remarkably displayed. In making this experiment on an animal, the vessel evidently contracts within the flesh. Thus it happens, that the spermatic artery and cord, drawn by the weight of the testis, will frequently after the section contract within the abdomen, if not properly secured.

It is this very circumstance that has induced me to propose for the operation of sarcocele, a modification, which is, after having perfectly separated the cord at the end of the first incision, 1st. To find out the *vas deferens*, which is easily indicated in the vascular mass by its firmness. 2dly. To have it held by an assistant. 3dly. To introduce the bistoury between this and the vascular mass. 4thly. To cut first this mass, leaving the canal uninjured. 5thly. Then to apply the ligature to the artery which is indicated by the stream of blood. 6thly. When this is completed, to remove also the *vas deferens.* It is evident that by this division, performed separately, we have the advantage of applying the ligature without a fear from the contractions of the artery, since the *vas deferens* to which it adheres, and which is not removed till the artery is tied, suffices to secure it. I have never performed this operation myself, but it is evident there is nothing to prevent this mode of operating, since the parts are sound where it is performed. Besides, I have always taught the pupils to operate in this way with facility, when the cord, in consequence of disease, having extended, must be removed very near to the ring; this mode of operation has appeared to me to afford great advantages.

I believe that the retraction of arteries that have been drawn out, and then their contraction, act an important part in the absence of hemorrhage attending most wounds produced by laceration—a singular phenomenon, by which such wounds are especially distinguished from those produced by a cutting instrument, even when some considerable vessel has been divided.

Several authors have quoted instances of such cases. Sabatier, in particular, in his work, has mentioned several instances.

SECTION III.

Vital Properties.

Properties of Animal Life—Sensibility.

ARE arteries possessed of animal sensibility?

The following is what we learn from facts in this respect:—

1st. The ligature of an artery will cause, at times, a painful sensation; but more frequently there is none. It is particularly in the spermatic artery that pain is sometimes smarting; but this might be referred to nerves.

2nd. I can affirm, without exaggeration, that upon more than a hundred dogs I have made experiments, in which the carotid artery has been employed to convey different substances to the brain: but in whatever manner I irritated it, either with the knife, acids, or alkalies, &c., the animal never gave the least token of pain. Numerous authors have obtained analogous results. I have even observed, that it is a further proof of the kind of insensibility in the nerves of organic life, which, as we have seen, are nearly every where distributed over the arteries.

3rd. In respect to the irritation of the common membrane of the veinous system, this is what I have noticed: the injection of a mild fluid, such as water, heated to the temperature of the animal, does not cause the least sensation; but an irritating fluid, such as ink, diluted acid, wine, &c. produces excessive pain, equal to that resulting from the irritation of our most delicate parts, if, at least, we are to be guided by the cries and agitation of the animal at the moment the carotid is injected with these fluids.

Contractility.

Animal contractility is totally wanting in the arteries. In fact, it could only arise from a connection between these vessels and the brain, through the medium of the nerves.

Now, 1st. Any irritation whatever produced in this last viscus, by causing convulsions in the organs submitted to the will, has no influence whatever upon the arteries. 2nd. Opium, which, in certain quantities, will paralyze these organs, leaves the arterial motion perfectly free. 3rd. If the spinal marrow be laid bare, and irritated or compressed, the arteries will neither increase nor slacken their action; whilst convulsions and palsies are produced in the voluntary muscles. 4th. The same want of effect is observed when arteries are subjected to different stimulants, whether these be applied to the nerves of the cerebral system, or to those that attend the vessels, without apparently providing them with filaments, or to those of the system of the ganglions, that are irregularly distributed, and in a considerable number, on their external surface. 5th. To remove all matter of doubt in this respect, I have chosen the most powerful mode of excitation—galvanism. It was in vain that the cerebral nerves were armed on the one part, and, on the other, the arteries annexed to them; the contact of these two opposed points did not produce on the arteries the motion it excites in the muscles to which these nerves proceed. The result is the same when the nerves of the ganglions are chosen for the experiment; on the one hand, I have excited the superior part of the mesenteric plexus, on the other, the arteries of the same denomination, previously divested of their serous and cellular coats; the contact absolutely produced no effect whatever. The arterial system, then, does not possess that motion which the action of the brain is capable of producing. All that has been written by different authors, particularly by Cullen, on the nervous power, on the action of the brain in the arterial system, is vague, illusive, and contrary to experience.

Properties of Organic Life—Sensible Organic Contractility.

Sensible organic contractility is very evidently wanting in the system we are considering. In whatever manner an artery of a living animal be irritated, it constantly remains in a passive state. 1st. It is very easy to make this remark by stimulating its external surface with the knife, or any other instrument. 2nd. The same remark is also made when the internal surface is excited, an experiment I have frequently repeated, as it is known that the heart is more irritable internally than without. 3rd. When cut longitudinally in a living animal, the edges do not revert as those of the intestines in a similar instance. 4th. Extracted from the body, no arterial tube has ever given the slightest sign of contraction, as the intestines, the heart, &c. 5th. If, in a living animal, or in one recently killed, the arterial laminæ be progressively removed, no vestige of that vibration of palpitation experienced in the organic muscular fibres under similar circumstances is ever felt; on the contrary, a kind of apathy, very analogous to that of the tendinous and aponeurotic fibres, &c., is observed. 6th. It has been asserted, that, by placing the finger on an artery, a contraction is felt. I have repeatedly made this trial, the contraction is infinitely less striking than has been stated. Moreover, it is evidently produced by the contractility of the texture. 7th. Lamere states, that, having intercepted blood in an artery between two ligatures, the parieties, although deprived of the influence of the heart, have continued to contract. This fact is positively incorrect. It was too important that I should have neglected it. I have therefore repeated that experiment ten times at least on the carotid artery: it was constantly attended with the following result:—the tube included between the two ligatures, and filled with blood, was actually impressed with real motion; but it was part of the general locomotion only of which it partakes with the whole artery, and which is produced by the impulse of the blood against the ligature corresponding to the heart. To be convinced of this, it is only requisite to lay bare that artery to some considerable extent, and we shall evidently perceive that the whole tube, either the part that is towards the heart, that included by the two ligatures, or the other, is agitated by the same general motion. 8th. Instead of blood, I have secured various kinds of irritating fluids in a portion of an artery: the same insensibility, the same deficiency of contraction in the coats, but the same general locomotion were the result. 9th. Several authors have produced contraction in arteries, by stimulating them with concentrated acids; this is true;—and I have also produced the same effect; but this is not the result of contractility—it is mechanical shrinking. It must also be noticed, that after such contraction, the arterial texture can never be restored to its primitive state; that the alkalies, which are in every respect as irritating as acids, whenever the vital powers are to be excited, pro-

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duce, in this case, no kind of effect: it is the same phenomenon during life as that which has been shewn to occur after death.

From this I should suppose it can no longer be doubted that arteries of themselves, and from their vital influence, have no kind of contraction. All that has been advanced in this respect arises, evidently, from the contractility of the texture. Thus on opening an artery between two ligatures, it instantly emits the blood, or any other fluid that had accidentally been injected; the same phenomenon is produced when only a single ligature has been applied to intercept the action of the heart, &c. It is so far true, that all these phenomena, and others similar to them, proceed from the properties of the texture, that they are produced in the corpse, provided the arteries are not in a state of putrefaction. If we fill any portion of the arterial system, and then open one of the tubes, it will instantly empty itself by contracting. The contraction produced by the deficiency of extension is precisely what characterizes the contractility of the texture: irritability, or sensible organic contractility, on the contrary, constantly implies the application of a stimulant.

Insensible Organic Contractility.

Insensible organic contractility, or tone, is very evident in arteries. In the large trunks, and wherever the pulsation is striking, its functions are exclusively confined to nutrition and to exhalation, if this, which I do not believe, takes place within the arteries. From the moment the influence of the heart on the blood contained in these vessels has ceased, that is to say, where the capillary system begins, then the tone also begins to influence not only the nutrition of the vascular parieties, but likewise the circulation performed in that system; it is even exclusively in virtue of the tonic forces that circulation, as will be seen, is carried on in these small vessels; the heart has positively nothing to do with it. I shall treat of this property in the general capillary system; here it only acts an auxiliary part.

In respect to organic sensibility, it evidently exists in arteries, since it can never be separated from the preceding contractility; like this, it is rather obscure in large trunks, which are only possessed of what is necessary for their nutrition.

From such a slight degree of developement of the organic powers in the arterial texture, it evidently results, that such affections as are especially under the influence of these properties are rarely seated in this texture. This is also demonstrated by observation.

1st. Acute affections are seldom observed in the arteries. Amongst all the bodies I have opened, very few had traces of inflammation in the arterial texture. I must notice, in this respect, it is requisite to be very cautious in distinguishing perfectly that redness which, as we have ascertained, is the effect of maceration, and even spontaneously produced in the corpse some time after death, especially in the cerebral arteries. This I say should be accurately distinguished from that which is produced by maceration.

In the one the arterial fibres are actually red; in the other they only appear so from the injection of their vessels. Does inflammation attack the common membrane of the arteries in inflammatory fevers? Of this I am perfectly ignorant. These simple cases are so very rare, especially in hospitals, that there is little or no opportunity of opening subjects to whom they have proved fatal; but admitting that such inflammation is produced, the scarcity of these fevers in their simple state would prove how little arteries are subject to inflammation. 2dly. Arteries are not more liable to chronic affections, excepting, on the one hand, aneurism, in which the arterial texture had undergone no change, but is merely ruptured, and in which its organic sensibility consequently acts but a very indifferent part; on the other hand, the bony incrustations, and the greater part of the alterations which are so frequent in the other textures, are never met with in this. This texture, in fact, with regard to the scarcity of organic alterations, should be ranged with the cartilaginous, the fibro-cartilaginous, the fibrous, and even the muscular, &c. These textures display in this respect a phenomenon opposite to that of the serous, mucous, glandular, and dermoid systems, &c. that are particularly characterized by their frequent alterations of structure. Now let us compare together the organic properties, the sensibility, the insensible contractility in each class of the textures, and we shall find them rather obscure in the first, where in the natural state they preside over nutrition only; whilst in the second, on the contrary, we shall see them strongly characterized, because they are connected with nutrition, exhalation, absorption, secretion, &c.

The difficulty with which the arterial texture inflames, and partakes of the various diseases of the adjoining organs, insures in numerous cases the freedom of circulation. What would become of this function if arterial texture, like the others, were so easily affected by surrounding diseases? Almost constantly placed near to parts that are obstructed, inflamed, in a state of suppuration, &c. if they were affected by contiguity, the large trunks particularly, a general disturbance in the circulation of the blood would soon be experienced. If we dissect arteries in the organic affections of the stomach, the liver, the spleen, &c. we shall find them sound, their volume only rather slightly increased, whilst a general obstruction seems to have involved and confused in a new mass all the adjoining textures.

Sometimes the coagulations in cases of aneurism adhere so intimately to the common membrane, that we are obliged to remove them by an instrument; but this adherence is completely inorganical; it is a kind of agglutination that would rather imply a deficiency of vitality in this common membrane, in the same manner as the facility with which the various colours are communicated to the epidermis implies such deficiency in respect to this organ.

Remarks on the Causes of the Motion in the Red Blood.

The red blood moves in the heart by a mechanism respecting which no difficulty arises. But a very important question remains undecided relative to its circulation in the arteries. In respect to this motion, do these vessels take an active or merely a passive part? When the physician studies the difference of the pusle, it is the state of the heart, or that of the arterial system, that he considers? From the absence of sensible organic contractility, as we have observed in the tissue, it is evident that its action must essentially be passive; that the motion, of which it is the seat, is communicated to it; that the heart is the great impulsive agent, in the pulsation of the arteries; that from this organ proceeds the impulse which these vessels merely obey; and that, consequently, in almost every case, the state of the pulse implies that the vital forces of the heart, and not the state of the arterial system, whose degree of vitality is more increased in the most frequent and considerable pulsations, than in the slowest and most feeble. Thus, in the convulsions produced by a wound, an irritation on the brain, &c. nerves, although the conveying agents, are quite in a passive state, or nearly so.

I shall now examine minutely this important question, which several physicians have regarded in quite a different sense.

The Influence of the Heart on the Motion of the Red Blood.

1st. The first reason that induces me to believe, that in respect to the vitality in the circulation of the red blood, the heart is all, and that arteries are essentially passive, is the comparison of the vital powers of these two organs, the astonishing activity of organic contractility in the heart, and the want of that property in the arteries. In fact, to be enabled to perform motion of itself, an organ must be endowed with a principle of motion, that is to say, must possess one of the two evident vital contractilities, the organic, and the animal; for no other vital forces have been found to exist in the organs of the animal creation, and it cannot be said that nature has especially formed one intended for arteries. Grimand admitted in these vessels a kind of active dilatation, that enabled them, according to his idea, to open of themselves, to receive the blood without the help of its impulsion. We shall find that both in the heart and in the organic muscles, this kind of motion may be correct to a certain degree. In this instance, however, it is quite a different thing, the heart will dilate of itself when it is empty, as is seen when taken from within the chest of a living animal, and then deprived of its contained fluid, because that organ has within itself the cause of its dilatation. In no instance whatever have I seen arteries thus submitted to an alternate motion, when empty, but they have constantly been contracted.

2dly. If arteries were by their vital contraction enabled to produce pulsation, irregularity of motion in aneurismal tumours would be unavoidable, since the arterial texture being in an unnatural state, must be deprived of part of its contractility, or this property must at least be altered. Now, the very reverse is ascertained. On the other hand, all organic diseases of the heart evidently disturb pulsation. Whenever there is an increase of the fleshy fibres, as in cases of aneurism, when the left ventricles become so thick, the pulse is strong: it is irregular, if the obstruction be seated in the mitral or aortic valves. If in an aged subject, ossification be merely confined to the arterial system, pulsation is undisturbed: if it exist at the origin of the aorta, or in the very heart itself, the pulsation is irregular. An artery might form a continued long tube, through which the blood would circulate as usual, admitting of no other distinction than that of pulsation. What I have said in respect to the chronic affections of the heart, must also be referred to the acute diseases of that organ. Syncopy stops its motions and pulsation ceases. Certain passions, as fear, anger, &c., seem to act as stimulants to that organ,—what follows? they increase the action of the arteries. All inflammations of the pericardium affect the pulse. This membrane, subsequent to inflammation, frequently adheres to the heart, at the same time the plura adheres to it also on both sides; so that it might be said, that the lungs and the heart form but one organ. I have seen four cases of this nature, in which the motions of the latter organ must have necessarily been very much limited. In these cases, the pulsation was low, irregular, and intermittent.

The more bodies I examine, the more I am convinced that whenever irregularity of the pulse has continued for some length of time, there is almost always an organic affection of the heart; from whence we are induced to believe, that the acute irregularities of the pulse, if I may be allowed the expression, do not proceed from an alteration in the texture, but in the vital forces of that organ, and that arteries have scarcely any connection with it. We are aware how very frequent these irregularities are in acute diseases. Since then, every disease of the heart essentially disturbs the pulse, and that, on the contrary, those of the arteries does not affect it, we must naturally conclude, that in this important phenomenon, the one is essentially an active, and the other almost a passive agent.

3dly. It cannot be doubted, that from the moment a ligature prevents an artery from receiving the influence of the heart, the artery ceases to beat. All the phenomena proceeding from aneurism, treated either by compression or ligature, establish this fact: if a contrary effect has in some cases been observed, it only proceeded, as I shall state, from anastomosis; and in such cases, it is also the heart that produces the pulsation both above and below the ligature. It is quite erroneous, as I have already observed, to assert that an artery may pulsate between two ligatures. In cases of aneurism, the artery being compressed below the tumour, frequently beats with additional force.

If we remove the arm from a corpse, and render it flexible, by steeping it for some time in a warm bath, then adapt a small tube to the brachial artery, and place the other extremity of the tube within the carotid of a living dog, one of the large species, the heart of this subject will instantly propel the blood into the amputated limb, and the artery will experience a kind of pulsation, undoubtedly less than in its natural state, but sufficiently strong to be felt, even through the integuments. I have frequently repeated this singular and astonishing experiment, which I shall occasionally mention hereafter. It had been suggested to me by another, which I have explained in my treatise of the membranes, and which consisted in causing the red blood to circulate in the veins, without locomotion it is true, but with a vibration evident to the touch, and a degree of rapidity nearly equal to that in the arteries. This last experiment would be sufficient to prove that the heart is almost the sole impulsive agent that causes the blood to circulate in arteries. In fact, every stream of blood proceeding from the veins is uniform, because the capillary system propels the circulating fluid gently into these vessels; whilst, on the contrary, it is thrown into the arteries by jerks, produced by the contractions of the heart. But, if a vein be laid open, and the red blood made to circulate by means of a curved tube, it will also enter by jerks, corresponding to the contractions of the heart. Excepting locomotion, a vein displays, in regard to the circulation of the red blood, the same phenomena as an artery; but if, on the contrary, the reverse experiment be made, (that is to say,) if a curved tube be adapted to a vein and an artery, so that the blood of the first may flow into the second, this will instantly be deprived of pulsation, unless the motion be continued by the collateral vessels, which will not happen if large trunks, as the femoral artery and its corresponding vein, be selected for the experiment.

It is, then, evident that all these experiments I have so frequently repeated, should have produced quite an opposite result, if, on account of their vital properties, the arteries were actively concerned in the circulation.

5th. The force of the heart causes the blood to circulate to a considerable extent through inert tubes adapted to arteries. If an inch of the carotid be removed, and a tube inserted in the two ends to fill up the deficiency, the blood will follow its course as usual, and cause the artery to pulsate under the divided part. I cannot conceive what could have deceived those that have obtained different results.

6th. If in two dogs, one end of a tube be adapted to the carotid of the one, on the side of the heart, and the other to the crural or carotid artery of its fellow, in the side opposite to that organ, the heart of the first, by conveying the blood, will cause the arteries of the second to pulsate. All my experiments upon death, and which are already published, have presented this phenomenon. Besides, in cases of aneurism, the pulsation of the artery exists below the tumour; and yet, here the two ends of the divided artery are separated, the cellular membrane only, by forming a cyst, serves to unite them; the blood then passes through an intermediate body which is not arterial.

7th. Let us adapt a tube to an artery, let the other end be provided with a pouch formed of skin, or oil-cloth, the blood will instantly fill it; and at every contraction of the heart it will experience a kind of pulsation: thus it is that the tumour of an aneurism pulsates, although essentially cellular. Whatever may be the organ that contributes to form the cyst, as long as it receives through the blood the impulse of the heart it will beat in a similar manner.

8th. May I ask whether the active dilatation of arteries would be sufficient to elevate the brain, to impart a motion to the leg crossed over the opposite one, to overcome the efforts of tumours situate in their courses, and which rise at every pulsation? To produce these phenomena, a more powerful organ is evidently required; now that organ is the heart.

9th. How could the pulsation in every artery be simultaneous, if that pulsation were not governed by a sole central agent? The whole arterial system suddenly impressed by the same stroke, rises and pulsates at the same moment. Is it not evident, that if the arteries contracted of themselves, the least derangement in one of the parts, the slightest pressure, &c. would unavoidably produce a discordance in their motions?

10th. No animal has pulsations unless he is provided with a heart, or a fleshy organ, distributed in knots, and divided by necks, as that in several insects; besides, have the pulsations of these substitutes for the heart been properly investigated? Thus it is that pulsation is never seen to exist in the system of the vena porta, notwithstanding that its hepatic half is disposed as the arteries.

11th. Blood flows from the two ends of a divided artery; but this is occasioned by anastomosis, and not, as I myself once thought, by a re-action in the end opposed to the heart. It is thus that an artery may sometimes beat below a ligature.

12th. I readily admit, that without the assistance of the heart the red blood might possess, in its great canal, a kind of motion; but that motion would be similar to the circulation of the vena porta, perfectly destitute of pulsation.

13th. Instances are produced in which the motion of the artery, although void of blood is continued as usual. I must confess that I do not conceive how this fact could have been ascertained; but were it really the case, it might be compared to that of the soldier who was said to stop the motion of his heart at will. What can be concluded from an insulated phenomenon, contradictory to all those nature every day lays before us? In respect to this it is not useless, I believe, to observe, that since sound physiology has advanced, and science has been pursued with a systematic spirit eager for truth, and anxious only to accumulate facts, no more of these extraordinary cases, in which nature seemed to have transgressed the bounds she had imposed upon herself, are produced.

From all that has been stated, it evidently, I believe, results, that in respect to the pulsation of the arteries, the heart is nearly the only powerful agent that gives motion to the fluids; that the vessels are, as it were, merely passive; that they obey the motion imparted to them, and are destitute of any derived from themselves, depending at least upon vitality. Thus has nature selected, to form the arterial texture, one of those in the economy in which life is the most obscure. In proportion as the heart is remarkable for its vital properties, so the arteries are remarkable for the want of them. They should be arranged with the cartilaginous, fibrous, and fibro-cartilaginous textures, &c. It was to prevent arteries from disturbing by their movements the unity of the impulse, that nature has thus reduced them to a passive state. Let us suppose that they are endowed with the same degree of vital powers as the intestines, what would become of life? The least convulsive contraction rather too strong in the aorta, or in the large trunks, by contracting their calibre too much, would obstruct circulation, and by acting in opposition to the heart, produce the most fatal consequences.

In the intestinal tube this phenomenon would only produce vomiting. In the arterial system, it would cause instant death. The more this subject is accurately considered, the more we shall be convinced how necessary it is that there should be, in respect to the arterial system, but one impelling agent, and that this system always inert should not impede the progress of the fluid.

I do not intend to say, that arteries cannot, in peculiar cases, contract from the vital influence; the skin that is not irritable is very much wrinkled by cold. But such cases must be very scarce; when they do exist, they cause an inequality of pulsation in both sides; an inequality that is scarcely ever observed in disease.

On the Limits of the Action of the Heart.

The heart then is the essential cause of pulsation; it is this organ that actuates all in the arterial motion: its influence has been too much exaggerated by several authors. They have admitted, that its impulse is sufficient to produce not only the arterial motion, but also that of the general capillary system, and even of the veins, so that in their opinion, the contraction of the left ventricle is the cause of that extensive course the blood takes from this to the right ventricle; but numerous proofs, as we shall perceive, fully establish that when this fluid has once reached the general capillary system, it is absolutely without the influence of the heart, and that it is then moved only by the tonic powers of these minute vessels; and, that for a still greater reason, all the influence of the left ventricle is perfectly lost to the veinous system. It is in these respects the authors alluded to have erred, and not in having admitted the influence of the heart upon the arterial system.

We are now, I believe, enabled to fix the limits of the heart's influence over the blood, by fixing them to that part where this fluid, in the general capillary system, is transformed from red into black. As it gradually enters these minute

minute vessels, the received impression is undoubtedly weakened, and thus insensible organic contractility supplies the deficiency; however, I am induced to believe that the motion which the blood has received from the heart is not entirely lost until it arrives at that point where the transformation takes place, so that it may be established as a general principle, 1st. That in the large trunks, in the branches, and even in the ramifications, the heart is all in respect to the motion of the blood. 2dly. That in the ramifications, the motion is produced partly by this organ, and partly by their vital powers. 3dly, and finally, That this vital action of the vessels exists only in the general capillary system. Pulsation then only exists to its full extent in the large trunks and the branches; in the ramifications it visibly declines and ceases in the capillary system. The arterial texture of the large trunks is undoubtedly provided, as we have seen, with insensible contractility. But on one part, the impulse received from the heart is so very powerful, and the column of blood so considerable, that the influence of this kind of contractility is useless; irritability only might have had some influence, but it does not exist in the arteries. On the contrary, in the capillary vessels, on the one hand, the shock impressed by the heart having gradually subsided, on the other hand, the streams of blood being very fine, require for their motion merely a kind of oscillation or insensible vibration of the vascular parieties. It is even this by which the two species of organic contractility are essentially distinguished. The one only acts on fluids contained in large quantities, as on the blood, food, wine, &c.; the other impresses the motion to fluids divided in minute streams; it presides over capillary circulation, exhalation, and secretion. The influence of the first is then particularly intended for large cavities, such as the stomach, the bladder, the intestines. That of the second exists in the capillary tubes only. As long as the blood remains together in a tolerable mass, it must necessarily be impelled by the heart, since the arteries being deprived of irritability are not calculated to perform that office. When it is in very minute threads it is then circulated by the insensible contractility of the vessels. This then is the part which the latter property takes in the system of the red blood. 1st. It exists in the trunks, branches, and the ramifications, but is useless as long as the influence of the heart is sustained. 2dly. This last influence gradually decreasing as it reaches the vessels of a lower description, the other begins to be more active. 3dly, and finally. The heart having ceased to agitate the blood in the general capillary system, insensible organic contractility or tone is the only remaining cause of motion.

Phenomena relative to the Impulsion of the Heart.

What part then do arteries take in pulsation? The following is what takes place in this important phenomenon: As arteries are incessantly filled with blood, the shock conveyed to them from the left ventricle is suddenly felt throughout the whole system to its most distant parts. Let us figure to ourselves a syringe, provided with an infinite number of branches proceeding from the main tube, which branches successively produce a number of smaller ones; by pressing the piston, all these ramifications being filled with fluid, it is evident that it will pass out on all sides from the open extremities at the moment the impulse is given. Now, let us suppose, that instead of the piston being forced, the side of the syringe could be suddenly made to collapse, the fluid would be instantaneously emitted through every issue. Another simile may render this more obvious:—If we strike the end of a long beam, the movement is suddenly felt at the opposite extremity.

From these instances, we may form a correct idea of what takes place at the very moment the left ventricle contracts. Much has been said about a flow of blood distributed in the whole arterial system, proceeding from the two ounces of blood conveyed to the arteries at every pulsation. The arterial motion might thus be conceived, if the arteries were empty at the moment of the contraction; but when filled, the shock is generally and suddenly felt with nearly the same degree of energy, as well at the extremities of arteries as at their origin. It is only in the ramifications that the motion is rather reduced. Let the arteries of a corpse be filled with water, and a charged syringe be adapted to the aorta, at the moment the piston is compressed the fluid will project from the aorta, or from any other artery, if an aperture that has previously been made be unclosed.

The idea generally entertained of the progressive motion of the blood is then perfectly incorrect. This fluid has been conceived to flow in the arteries nearly in the same manner as water runs in a stream; but this is not the case. At each contraction of the ventricle it suddenly experiences a general motion, that is felt in the extreme parts. Shall we make use of another simile? Let us again suppose a syringe, to which a continuation of elastic tubes arising from each other are adapted; at the very moment the impulse is given, these tubes are seen to fill simultaneously, to straighten and give exit to the fluid, if their extremities have been left open.

It is not by the contraction of the arteries that the blood is forced to their extremities. This is so correct, that if one of these vessels be opened at a distant part from the heart, every jerk of the blood, on being expelled, will correspond to each contraction of the ventricle. Now, if arteries, by contracting, were intended to convey the blood to every extremity, their contractions and expansions would unavoidably alternate with those of the heart; but if this were the case, each pulsation of the arterial supply should correspond to the dilatation of the ventricle, whilst, as I have stated, it is quite the reverse.

From this we may conceive how very incorrect was that opinion generally received, and which I had myself professed for several years, namely, that the auricles contracted with the arteries, and the veins with ventricles. The circulation of the red blood was explained in the following manner: 1st. The pulmonary veins propel the blood into the left auricle; 2dly. This, by contracting, impels it into the ventricle that dilates to receive it; 3dly. The ventricle then contracts and forces it into the aorta, that is dilated at the moment of contraction; 4thly. This also contracts to distribute it in all parts of the body. This last action does not take place. I defy any one ever to observe it, as the others, in a living animal. Let us examine as closely as possible a large artery laid bare, it will rise, but hardly dilate in its natural state; neither is it seen to contract but in a slight degree. Contraction of the left ventricle, general motion in the arterial blood, and the passage of that fluid into the capillary system, are three things that take place at the same moment. This simultaneous motion is precisely similar to the stroke of the beam, which is felt at one end at the same time that it is communicated to the other. A very correct idea of circulation might be conceived, by examining the mesenteric arteries through the peritoneum; when the abdomen of the animal has been laid open, they are seen simultaneously to rise and pulsate both at their origin and extremities.

It is impossible ever to form a correct idea of the arterial motion, by considering the volume of blood spreading at each contraction in the arteries, and then arriving successively at the extremities. If we read every author on circulation, we shall find that no point has been so frequently and so extensively discussed as the course of the arterial blood, and yet none admits of more doubts and is more involved in darkness. Why is this? Because all have set out on a wrong principle, and all consequences are naturally incorrect when the principle itself is erroneous.

It is not the stream of blood emitted from the ventricle at each contraction that is impelled into the capillary system, but that part of the fluid that was contiguous to this system at the time of contraction; the same as in the syringe; it is the part that rests in the extremity of the tube, and not that with which it is in contact, that is expelled; from whence it results that a certain time elapses before the blood can be conveyed from the heart to the general capillary system, that it remains in the arteries during a particular number of contractions, and is expelled in succession only; a favourable circumstance to promote the intermixture of the different principles it is composed of.

From this manner of viewing the arterial motion, and which is the only correct one, the only one that is admissible, it is evidently impossible that the curvatures should obstruct this motion, an inference that is likewise established by numerous facts.

I also consider as void of foundation, all that has been set forth in books on physiology, in respect to the causes of obstructions in circulation. 1st. By its transition from a narrow canal into one more extensive, and by the conical form of the general arterial system; 2dly. By friction; 3dly. By the angles; 4thly. By anastomosis, in which the impulse is opposed, &c. &c. All this would be perfectly correct if the arteries were empty at the time of contraction, because then the blood would really undergo a progressive motion; but in the general and simultaneous shock received by the whole mass in the arterial system, these causes evidently do not exist. I shall again have recourse to the trivial but very correct simile of the syringe. Let us imagine that a tube winding in a thousand directions, forming numberless angles, asperities, and internal projections, &c. be adapted to it: If the tube and its branches are full at the moment the piston is pressed, the fluid will instantly project from this tube as perfectly as if it had been straight and short. It is true that all those causes of opposition that might have some effect if the arteries were empty, at the moment the blood is conveyed into their canals cannot operate when in their ordinary state, and that a number of judicious physiologists, who had even admitted of obstructions in circulation, have found by their experiments that the motive was every where the same either in the ramifications or in the trunks. How is it then that this did not undeceive them ? We are well aware that pulsation is the same in every part of the arterial system—but how could this coincide with obstructions ? The opinion respecting the rapidity of the course of the red blood has retarded the progress of physiology with regard to circulation. This degree of rapidity cannot be properly ascertained, because the motion is not successive, because, correctly speaking, the blood does not flow ; it is abruptly propelled by a general shock that evades all kind of calculation.

Physicians have paid great attention to that motion of the fluids in which, as in the stream of a river, the particles are successively displaced; but that abrupt motion of a whole mass, (if I may use the expression,) experienced in canals, where they are restrained on every side, and where the impulse is received at one end, has been less considered.

Remarks on the Pulse.

Two points in this respect have been very evidently proved. 1st. That the heart is the special agent for the arterial motion, and that arteries in this motion act nearly a passive part. 2dly. That it consists in a general shock, suddenly experienced by the whole mass of the red blood, felt at the very same instant in the most distant parts as well as in the trunks, and not in a successive progression of the fluid supplied by the left ventricle.

It now remains to examine how the heart can, by that abrupt and instantaneous motion, produce pulsation. We have many difficulties to overcome on this point; but it cannot be doubted that the locomotion of the arterial system has great influence in the production of this phenomenon. At the instant the vascular mass is thus conveyed from the heart to the most distant parts, as it were by a total motion, it unavoidably tends to straiten the arteries, particularly when incurvated. This action necessarily determines a motion, which produces the pulsation of the artery.

With respect to dilatation: it scarcely exists in the ordinary state; however, if the artery be gently compressed, the blood is exerted to dilate it, and that exertion encreases the sensation of the pulse. Jadelot had even gone so far as to admit that this alone constituted pulsation. On the other hand, if, at the contraction of the heart, a considerable quantity of blood be received in the arterial system; if some resistance be met with in the general capillary systems, arteries may also be dilated; but then, it is not their contraction that propels the blood into the capillaries; such return is only consecutive. In fact, at the very moment of contraction, on one part, the blood, in proceeding from the ventricle, enters the arteries, and on the other part, projects from these into the capillary vessels: these two phenomena take place at the same instant, since they are produced by the very same impulse;—hence, whenever contraction exists in the artery, a movement derived only from the contractility of the texture, this contraction does not propel the blood, but takes place because the fluid has been impelled in the capillary system; at the moment of contraction the artery returns to its former state, because it is no longer extended, and not because it is actually distended. In this way the arterial contraction may alternate with that of the left ventricle; but authors have not understood it in this sense. There are, then, two periods in the movement of the red blood:

1st. Contraction of the ventricle, a slight dilatation in the arterial system caused by the propelled fluid, general locomotion, passage of part of the veinous blood into the capillary system ; all these phenomena are produced in the very same instant ; it is at the time of the diastole that the pulse strikes the finger. 2dly. In the succeeding interval the ventricle expands to be re-filled, being less replete with blood ; arteries, in some degree relax ; they all return to the different parts from which they had been previously raised. This state, which happens during the systole, is in respect to the arteries purely passive, whilst the contrary opinion has been held.

As very little blood is propelled at each pulsation from the ventricle, which is never completely emptied, and that on the other hand, at the very moment a quantity of this fluid enters the arteries, some is expelled from the part opposite to the heart, the arterial dilatation, and consequently the contraction, are very trifling ; thus they can never be perceived. Besides, the contraction, if really present, would not be perceptible, because, when the contractility of the texture acts, it produces a slow, gradual and insensible motion, a real shrinking ; whilst contraction produced by irritability is abruptly and instantaneously performed, and produces a motion striking to the eye.

I cannot insist too much upon this positive fact, namely, that if arteries are in some degree contracted at the moment the pulse ceases to beat, it is not because they contract to expel the blood, but because the blood that has passed to the capillary system does not sufficiently dilate them, it is contractility for want of extension. This shows how the flow of arterial blood proceeding from an opened artery, corresponds with the dilatation of these vessels and the lessening of the stream with their contraction. But according to the opinion commonly admitted, quite the reverse should be the case.

The dilatation and contraction of arteries being very trifling, and even nearly wanting in their natural state, it appears that the essential cause of pulsation consists, as Weitbreck has judiciously observed, in the motion of the arteries, a locomotion general and spontaneous throughout the whole arterial system; but not consecutive, as that author has understood it. I shall not now relate the proofs of this motion, they are every where to be met with. I shall only observe that it is so striking in living animals, that whenever circulation has been attentively observed through their means, it is impossible to deny that it exists. Besides divers causes may produce alterations in the pulse; these causes are, 1st. Those relating to the heart, nearly the sole impulsive agent; thus the sensible organic contractility of this organ, being increased, diminished, or affected, sympathetically by any cause whatever, may occasion it to contract quicker or slower, or with more irregularity than usual from the same stimulant: thus, the diseases of its organization must unavoidably influence its motion. 2ndly. The blood impregnated with the various natural or morbid substances, is a stimulant more or less capable of affecting the motions of the heart. 3dly. The general capillary system, accordingly as it receives a greater or less quantity of the circulating fluid, or refuses that conveyed by the arteries, &c. must naturally produce numberless varieties in the motions of the pulse, Very few cases relate to the arteries.

If we now reflect on the causes, almost innumerable, that relate to these three principal heads, we shall no longer be amazed at the prodigious varieties that the pulse presents in the state of health, and more particularly so in that of disease; however, this question will not be treated of here in its full extent; suffice it, that I have exposed the principles; the consequences, which, as we know, are so essentially important to the physician, will be afterwards considered. By the divers sketches I have produced, it may be perceived in what a false point of view almost all authors have regarded the motion of the blood, and what incorrect ideas they had formed to themselves of its circulation. Experiments on this head have only served to create confusion; it is a work that requires to be completely renewed, either with the materials already selected by several judicious authors, particularly by Haller, Spallanzani, Weitbreck, Lamure, Jadelot, &c. or with new facts. I have just presented the rudiments of this work.

We have seen how much the firm and elastic structure of the arterial texture is accommodated to the locomotions of arteries, and how the flexures of these vessels influence them, I shall add, that the loose adherence they contract with the adjoining parts, and that their constant position in the cellular texture, contribute essentially to this motion.

If the red blood circulated in the veins, instead of pulsation, a kind of vibration would be left under the finger, as in varicous aneurism. There would be no motion, if the arterial parieties were formed of the dermoid, mucous, or serous membranes, &c.: the impulse would be productive of different phenomena.

There are then two circumstances relating to the pulse. 1st. Impulsion of the blood, a sudden and general motion in the mass, by the contraction of the heart. 2ndly. Locomotion of the arteries, an effect produced by this fluid on the arterial parieties that transmit it. The first is the most essential; in respect to the second, it would vary if the arterial texture that occasions it ceased to be the same: it depends upon this texture, and is not essential to circulation.

When an artery is removed from the extremity of its trunk, locomotion is less striking in this part, because less resistance is opposed to the course of the blood.

When an artery has been opened laterally, two opposite currents of the fluid are produced, which are directed towards the opening, and unite in a single stream. One of these is direct; the other proceeds from anastomosis. It is the very same thing as when an artery being divided the blood flows from both ends.

If an artery be totally divided, a greater quantity of blood is produced in a given time than would otherwise have passed to the capillary system, which system presents more resistance. The rapidity of circulation ought not to be calculated by the hemorrhage consequent to wounded arteries.

Sympathies.

We have seen that arteries, on account of the obscurity of their vital powers, are rarely the seat either of acute or chronic affections; consequently they produce but very little influence on the other organs. Thus, with the exception of a few painful sensations produced by sympathy, and experienced in cases of aneurism, this influence of the arterial texture over the other systems scarcely exists. In one or two instances I have perceived convulsive motions produced by injecting a very irritating fluid into arteries. These sympathetic motions are very easily distinguished from those of pain in an animal struggling to extricate itself: they consist of violent tremors, or contractions, like those of tetanus. It is not necessary to say, that the carotids should never be selected for such experiments, because the irritation of the brain, from the direct application of the injected fluids, would produce convulsions, as an immediate consequence, and not sympathetically. Besides, the experiment would instantly terminate in death, if the carotid were selected for that purpose.

On the other hand, as arteries have no sensible organic contractility, scarcely any animal sensibility and little tone, other organs would have little power to produce sympathies in this system through their influence, because to bring a vital property in play in any part whatever requires that this vital property should exist in that part, and even to a considerable degree. Thus the innumerable variations of the pulse, which are the produce of sympathies, are all essentially seated in the heart, and not in the arteries. Sympathies then cause the heart to contract and interupt its motion, as stimulants or sedatives when applied directly over this organ; that is to say, by acting on its sensible organic contractility. When an aneurism is ruptured in a fit of passion, or in the act of coition, an instance of which I have seen with Desault, the cause is in the motion of the blood, which is suddenly increased. It is not the arterial tissue that has been influenced by passion; besides, upon what could sympathies act in arteries? It could not be either on the elasticity, or on the contractility of the tissue, which are however the only properties calculated to contract these vessels. Let us observe, in fact, that sympathies never excite more than one of the vital properties, because they are themselves purely vital phenomena. Every physical power or property of the tissue cannot take place under their influence: this is an observation of importance.

Besides, as arteries are every where so distributed in the organs, that they form, as it were, a part of their substance, it would be difficult to distinguish what belongs to them, particularly in respect to sensibility, from what peculiarly appertains to these organs.

ARTICLE V.

Developement of the Vascular System of the Red Blood.

SECTION I.

State of that System in the Fœtus.

The fœtus differs essentially from the infant, inasmuch as these two great vascular systems form but one, since the foramen ovale on the one part, and the arterial canal on the other, establish between them a direct communication. This communication is the more remarkable as the subject is nearer to the time of conception. The more we approach the event of birth, the more these apertures are contracted. 1st. In the first months the foramen ovale is formed by two projections in the form of a crescent, their concavities directed towards each other, and leaving between them an oval space, gradually decreasing, because these two productions gradually approach, tending to cross each other, which actually takes place after birth. 2dly. The arterial canal contracts, in proportion as the pulmonary artery dilates.

As long as these two apertures remain free, which is constantly the case with the fœtus, both systems, as I have stated before, evidently form but one; from whence it clearly results that the circulating fluid must unavoidably be of the same nature, and that there cannot be two different kinds in the fœtus, as is constantly observed in the adult. This is, in fact, a remarkable distinction between the two stages. 1st. I have frequently dissected Guinea-pigs in the parent's womb; their vessels have constantly appeared to me to contain the same fluid, which was of a darkish colour, as the veinous blood in the adult. This experiment is easily performed. The abdomen being laid open, the insulated pouches in the womb belonging to each fœtus are then successively divided. When one of these pouches has been laid bare, the membranes must be divided, then also the belly of the young animal, without injuring the umbilical vessels. The transparency of the parts renders it easy to perceive the similarity of colour in the blood of the vena cava and of the aorta. The same remark applies to the superior parts; the same kind of blood flows from the carotid artery or the jugular vein when they are opened. 2dly. I have made these observations at three different times in the fœtuses of dogs. 3dly. It is well known that the blood of the umbilical arteries is constantly black; every accoucheur has ascertained this fact. 4thly. It cannot be doubted that the change of the dark blood into red proceeds from the contact of air in the lungs; the fœtus being unable to perform that function, cannot then be provided with this kind of blood. 5thly. I have frequently dissected dead fœtuses in the parent's womb, but the blood of the arteries and that of the veins has always appeared to me of the same nature. It is true that this last instance is not a very conclusive proof, since admitting that red blood existed, its stagnation only in these vessels, if continued for a certain time, would, as Hunter as judiciously remarked, be sufficient to make it black.

The preceding facts, besides, suffice to establish as an indisputable fact, the identity of the blood in the two systems of the fœtus; an identity existing, at least in the outward appearance, if it does not really exist in the intimate composition of the fluid. It is for chemistry to enlighten us on this subject.

How does it happen that at the very moment dark blood penetrates into the arterial system of the adult, severe effects ensue, that soon asphyxia and then death is produced, whilst in the fœtus the dark blood circulates in arteries without occasioning the slightest injury. It is a very delicate question to resolve, and yet these two contradictory facts are equally certain. The difference in the nature of the blood in the fœtus might perhaps serve to remove the difficulty, if this difference were better known. In fact, although this fluid, from its colour, is assimilated to that of the veins in the adult, yet it does not seem to be exactly the same; it has a greasy feel, of which the former does not partake. In the corpse it is never found coagulated like this, but constantly in a fluid state, like the blood of those who have died from strangulation. Fourcroy has not observed any fibrous matter in this fluid. He has ascertained that it does not become brittle from the contact of air, that it contains no phospheric, salts, &c. It is then highly probable that if the circulation of the dark blood proves fatal in the arteries of the adult, whilst it circulates with impunity in those of the fœtus, this only proceeds from the difference in the nature of the two fluids. Besides, it must be remarked, that there is a great difference in the functions of the fœtus and those of the adult. The former has scarcely possession of any animal life ; and is deficient in several organic functions. The connections between the organs are of a very different nature from what they will become subsequent to birth. Not even the slightest analogy can be established, in this respect, between the fœtus and the infant. Thus have we observed that the experiments upon life and death produce quite different results in animals endowed with red and warm blood, and in those only provided with red and cold blood, which, in some points of view, rather approach the organization of the fœtus. No parallel then can be drawn between the fœtus and the infant in respect to injury of the phenomena of respiration, such as that whose causes I have sought in my experiments, since the organization relating to these phenomena differ so essentially from each other.

Although I have stated that the blood of the two capillary systems are united into one circulation, yet there exists, particularly in the first periods, a kind of insulation in the general mass of the fluid ; an insulation which Sabatier first noticed accurately ; and which results from the manner in which the apertures of the foramen ovale, and of the ductus arteriosus, are disposed. This separation divides the vascular masses into two. In this respect the circulation of the blood in the fœtus is performed as follows:—

1st. All the blood received by the trunk of the inferior vena cava, either from the capillaries of the lower parts, from those of the abdomen, or from the placenta by the umbilical vein, instead of proceeding as in the adult to the right auricle, completely enters the left through the foramen ovale, whose superior orifice is so disposed, that no part can be mixed with the blood of the superior vena cava, so that, upon proper investigation, it is seen that it is actually with the left auricle that the inferior cava is continued. This is the reason why this auricle is proportionally as much dilated as the right, for if it only received the blood of the pulmonary veins, this supply being very sparing, it would be very much contracted. From this auricle the blood proceeds to the left ventricle, which transmits it to the aorta, from thence it enters the carotid and the subclavian divisions, aud these in turn impel the fluid through numerous ramifications in the capillary vessels of the head and of the upper extremities.

2dly. After having remained some time in this system, the blood returns through the various branches of the superior vena cava to the right auricle, where it is prevented from mixing with the preceding by the upper margin of the foramen ovale; from this auricle it proceeds to the ventricle; this transmits it to the pulmonary artery, which sends a small proportion of this fluid that is returned to the left auricle by the veins of the same name, but which transmits almost the whole through the arterial canal in the descending aorta below the origin of the carotid and subclavian arteries, in which the first species of blood circulates. This is conveyed by the branches and ramifications of the aorta into the capillary system of the abdomen and of the inferior parts; the residue is afterwards expelled through the umbilical artery, and lost in the placenta.

From what we have just stated, it follows, that notwithstanding the continuity of the two great vascular systems in the fœtus, there exists, during the first months of conception, a kind of separation of the blood they contain, that there are, as it were, two systems quite different from those that will afterwards exist separately in the adult.

The first of these systems derives its origin, 1st, from all the capillaries of the abdomen, of the inferior parts, and even of the placenta; 2dly. Its common trunks below, are the inferior vena cava, and above the four-fold branch named the aorta ascendens; 3dly. The left side of the heart is its impulsive agent; 4thly. It terminates in all the capillary vessels of the head and of the superior parts. The second begins in these last capillaries, and consists, 1st. Of the superior cava, and of what is termed the aorta descendens for its trunks; of the right side of the heart for its impulsive agent; 3dly. Its termination is in the capillaries of the inferior parts.

In the early months of conception, the blood is then, as Sabatier has judiciously observed, evidently divided into two circulations that cross each other in the figure of an 8; in each it proceeds from one assemblage of capillary vessels to another, with this distinction only, that instead of circulating between the pulmonary and the general capillary system, as in the adult, it moves between the superior and inferior parts of the last-mentioned system. In this respect it is then correct to say, that, in the fœtus, the inferior and superior parts are opposed to each other in the same manner as the lungs are in the adult to the whole body.

This complete opposition in respect to circulation between the upper and lower parts of the fœtus in the early times of conception is probably the source of the difference that will afterwards exist in these parts. Every physician has noticed this difference in diseases. If the linea alba is found in different cases to divide the affections of the right side from those of the left, the diaphragm also seems to mark the limits for several diseases. Who is not aware that scorbutic spots are more common in the lower regions; that serous infiltrations are more frequent in these than in any other parts; that ulcers most commonly affect the lower limbs; and that, on the contrary, cutaneous eruptions occur more generally in the upper parts of the body, &c. Bordeu, who has said so much respecting the division of the body into superior and inferior parts, who admitted one kind of pulse to precede the evacuations of the superior organs, and another as the harbinger to those of the lower, has undoubtedly too much exaggerated this counterstate of the two halves of the body; but it is not the less true, and I believe highly probable, that the mode of circulation in the fœtus is the primitive source.

After the first months of conception things begin to change. The quantity of blood conveyed through the pulmonary artery was at first very trifling, because such was the dilatation of the arterial canal, that it directed nearly the whole into the aorta descendens. This canal gradually contracting, the pulmonary arteries dilate, and then a larger quantity of blood traverses the lungs to be returned by the pulmonary veins to the left auricle, that transmits it in the ventricle of the same side, by which it is propelled into the arch of the aorta; then the mechanical action of the circulation here above stated begins to alter, and approaches more, as we shall see, to that of the infant.

This first mechanism, however, still predominates for some length of time; from whence it results, that during the greater part of the time the infant remains in the parent's womb, it is the left ventricle that propels the blood to the superior parts, whilst the inferior parts are supplied by the impulse of the right ventricle, but as the parieties of the first are evidently much thicker than those of the second, and as the heart is more distant from the lower than from the upper parts, these receive a more powerful impulse than the others. From thence, may be derived a new source of the difference between the two regions of the body; from thence, the more active nutrition in the superior part; from thence, the degree of vital energy it continues to possess long after birth, and which exposes it, in the head particularly, to a much greater number of affections than the inferior is liable to.

The more we approach the moment of birth, the more will the pulmonary artery convey blood to the lungs, and the less will this fluid be admitted through the arterial canal, because it is only gradually, as I have stated, that the whole mass contained in the body will, at the event of birth, flow through the lungs. Although prior to this it has undergone no change in this viscus, yet it has not circulated in it the less, to habituate it, undoubtedly, to the continued circulation for which it is intended after birth. The quantity of fluid then is greater in proportion to the time the pulmonary artery has existed, and less compared with that of the arterial canal. This disposition most evidently commands a corresponding one in the foramen ovale: in fact, if in proportion as the arterial canal contracts, this were not also reduced, the whole mass of the blood would finally accumulate in the superior parts; because instead of proceeding from these to the inferior parts, it would be wholly returned by the left auricle and ventricle. As the canal contracts, the foramen ovale undergoes the same change, the blood of the inferior cava, which can no longer pass entirely, begins to mix with that of the superior, and to enter the right auricle, then into the right ventricle; after which, it returns by the lungs to the left auricle and ventricle, and to the aorta. What results from this? that this artery begins to receive from the left ventricle a much greater supply of blood than can force its way through the carotids and subclavians: a part of that which reaches it flows back in its descending trunk, and is conveyed to the inferior parts.

In consequence of what we have just stated, it follows that the two kinds of blood in the fœtus are nearly separated during the first months; the whole of the blood proceeding from the inferior vena cava passes the ascending aorta, and all that flows from the superior cava is thrown into the descending part of that artery, the lungs receiving hardly any other supply for their nutrition than that of the bronchial arteries. But in proportion as we approach towards birth, these two species of blood begin to mix together, and circulation takes an intermediate course between that of the adult, and what takes place in the first months after conception. At the instant of birth, the foramen ovale and the arterial canal being considerably contracted, circulation is carried on in the womb of the mother nearly in the same manner as it is afterwards continued; the only difference existing, is, that the fluid is of the same nature, because respiration has not commenced. The sudden change of circulation at the instant of birth relates particularly to the introduction of the red blood in the economy. In respect to the mechanical phenomena, they have been gradually brought on by the regular contraction of the two openings of communication. The blood has ceased by degrees to move from the inferior to the superior capillary vessels, and has been accustomed to proceed reciprocally from both to those of the lungs.

It would be difficult to account for the phenomena of circulation, by admitting that there is a sudden change at the moment of birth. A proper investigation of the foramen ovale and of the arterial canal, at the different stages of pregnancy, is sufficient to show that they decrease progressively, and that the phenomena consequently occur in succession; so that, if the fœtus were to remain in the womb beyond the time prescribed by nature, and that contraction to be progressively continued in the foramen ovale and arterial canal, the circulation would be performed in the same manner as in the adult; that is to say, solely from the capillary system of the lungs, and that of the other parts. The only distinction would be in the uniformity of the colour, because it would proceed to the first system without having been placed in contact with the air.

I do not intend to say, that the remainder of the blood that flowed through the arterial canal is not suddenly called to the lungs by the admission of the air; but undoubtedly this kind of sudden deviation exists only in respect to a portion of the blood in the pulmonary artery. Previous to birth, a part of the fluid was already conveyed through the lungs, although its cells were empty.

In general there is a constant proportion between the quantity of blood the right ventricle conveys to the lungs, and that which the left propels to the inferior parts. The more the first increases, the more the second abounds: this last is evidently the greater part of that which enters the upper parts of the body.

These three things—1st. The quantity of blood in the inferior cava, which unites with that from above, and passes into the right auricle. 2nd. That, which, proceeding from this ventricle, crosses the lungs, and is returned into the left auricle. 3rd. That portion which, from the left ventricle is projected to the aorta descendens, gradually increase as the fœtus approaches the period of birth.

The aorta descendens undergoes in its capacity no changes whatever in consequence of these deviations. In fact, whether it receive the blood from the arterial canal, or this fluid be directly transmitted from the left ventricle through its origin, it is the same in respect to this artery. Its parieties continue to increase in an uniform manner: the whole depends upon the gradual contraction which the arterial canal and the foramen ovale undergo.

In general, the whole of the vascular system is, in respect to its great developement, very remarkable in the fœtus. The arteries are proportionally much larger: this answers to the size of the heart, which, at this age, is very much developed; their comparative state being nearly the same as that of the nerves and the brain.

The developement of the arteries, however, is not, like that of nerves, nearly uniform in all its extent; in general these vessels follow the very same order as that of the parts to which they are distributed. Thus, in the upper parts of the body the cerebral arteries are much larger than those which resort to the face: amongst the latter, the ophthalmic is greater than the nasal, the palatine, &c. In the chest, those of the thymus gland are proportionally larger than at a subsequent period. In the abdomen, from the state of the gastric viscera, there are very considerable arteries. In the pelvis, on the contrary, the arterial system is very limited, because the viscera are small, and their nutrition is almost overlooked. The arteries are proportionally more diminutive in the upper than in the lower extremities, particularly so in the early periods; for towards that of birth the proportion is nearly the same.

The arterial texture is incomparably more elastic in the fœtus than in the adult; it is more readily extended; and they are not so easily divided by the application of the ligature. Aneurisms are scarcely ever met with in the infant.

In the fœtus, a number of minute arteries ramify in all directions in the parieties of the large ones, which are frequently, we may say almost livid, with them. To observe them accurately, it is necessary that they should be examined at this age. Does this abundance of vessels dispose the arteries at this time to inflammation, which is so rare at the later periods of life? I have not observed that it is the case.

In the early period of conception, the arterial layers and fibres are not very distinct in the fœtus: one might say, the substance of the artery is homogeneous. It is, however, much firmer than the adjoining textures, and corresponds to that of the heart. Intended to distribute to the nutritive substance to every part, arteries must unavoidably precede every other organ, in respect to nutrition. This premature increase, which is constantly concomitant with that of the heart, would alone be sufficient to prove that arteries develope themselves, and are not perforated in our internal parts, as Haller asserted, by the impulse of the heart. Besides, this manner of admitting of their mechanical formation, is evidently contrary to the known laws of the animal economy.

SECTION II.

State of the Vascular System of the Red Blood during Growth.

At the instant of birth, two important revolutions take place in the system of the red blood; 1st. A mechanical action, as it were, with respect to its circulation; 2dly. A chemical action in the nature of this fluid. The former consists in the blood ceasing totally to flow through the foramen ovale, the ductus arteriosus, the umbilical arteries and vein; the latter on the formation of the red blood. This will be immediately considered.

At the moment the fœtus is born, it meets in all that surrounds it with causes of strong excitement. Its cutaneous surface, and all the organs of the mucous surfaces, are powerfully stimulated. The sensations they experience are even painful, because there is a great difference between the liquor amnii and the bodies with which the fœtus comes in contact at the moment of the birth, and every abrupt transition in sensations is always attended with pain. Habit will soon destroy this; but it is not the less real at birth, and it may be said in this respect, that the moment of birth is as painful to the infant as to the parent. Now as every lively sensation is always attended with great motions, a general agitation succeeds to the impression the fœtus experiences after delivery. Every muscle, including the intercostals and the diaphragm, are all called into action. The air which already filled the mouth and the trachea, rushes through the lungs, imparts to the blood a reddish hue, is afterwards alternately received and expelled until death. The first inspiration is then, in this first point of view, a phenomenon analogous to every motion which the change of external excitement suddenly produces at the event of birth in the voluntary muscles of the fœtus.

The act of respiration, however, is essentially important to life, since it forms a new mode of connection between the organs, depending exclusively upon this cause. I presume that some unknown principle, a kind of instinct in short, induces the infant at the moment of birth, to contract the intercostal muscles and the diaphragm. This instinct, which I cannot account for, and of which I cannot even convey the slightest idea, is the very same that induces the infant, on leaving the parent's womb, to move its lips, soliciting the breast, as it were, for its new and natural supply. It certainly cannot be said, that this motion is caused by the external and powerful impressions to which it is subjected. Such impressions will produce agitation, and irregular motions, as if struggling to liberate itself, and not an uniform motion evidently directed towards a particular end. If the different classes of animals were to be examined at the instant of birth, we should see each of them perform particular movements, dictated by their peculiar instinct. Young quadrupeds seek the teat of the mother, chickens grain for food ; the carnivorous bird instantly opens its beak, as if to partake of the prey that is conveyed to them by the mother, &c.

In general, it is very essential to distinguish properly those motions which, at the moment of birth, are derived from the new excitements experienced by the fœtus, from those which result from a kind of instinct, from a cause we are unacquainted with. It is my opinion that the act of respiration arises from these two causes, and more particularly from the latter.

I shall now proceed to the mechanical phenomena respecting circulation. At the instant the lungs change to a red colour the dark blood received through the pulmonary arteries, they also claim in some measure the whole quantity of this fluid which still continued to flow through the arterial duct; this no longer transmits any thing to the aorta, which, in several instances, is still found more or less dilated; for we must observe, that at the moment of birth it is hardly ever completely obliterated. I have even noticed that its contraction at this time varies astonishingly. How then can it be accounted for, that blood circulates in it no longer? By the very same reason that food is not received into the ductus choledocus, the lacteals, or the pancreas, although it crosses their orifices, undoubtedly because the peculiar sensibility of this canal repels the new veinous blood of the fœtus, which is no longer conveyed from the placenta, because that part, coloured in the lungs, will no longer mix with it. It is certain that no mechanical reason can be produced for this change in circulation; it really exists, however, and is evidently connected with the laws of vitality. Besides, the motion of which the lungs have become the seat, the dilatation, and more particularly the new excitement from the contact of atmospheric air, by stimulating the capillary circulation, facilitates also that of the two pulmonary trunks, and induces the blood to take this course in preference to that through the arterial duct. It is in this respect, I have stated, that the lungs attract the blood from the pulmonary artery. Does it not happen, that the irritation seated in peculiar tumours attracts this fluid in greater quantity? Is it not from this that the arteries of these tumours dilate, increasing two or even three-fold in diameter? Now what is gradually brought on in such cases, is instantly produced in respect to the blood that circulates till birth through the arterial canal, although in a trifling degree, as I have before stated, from its progressive contraction. The very same reason that compels the whole mass of blood of the pulmonary artery to flow through lungs, causes the foramen ovale to close. In fact, this foramen is disposed at birth in such a manner, that the valves have even so far approached as to cross each other, so that, whenever they are pressed together, the communication between the auricles is actually closed. Now the red blood entering the left auricle through the pulmonary veins, presses the valve of the foramen ovale corresponding to it, against the other, and consequently obstructs the fluid of the inferior venæ cavæ, which was proceeding to enter it: this flows into the right auricle. When, however, this auricle contracts to transmit the blood to its ventricle, instead of propelling it through the foramen ovale, it unavoidably forces the two valves against each other, and obliterates them. In examining with due attention the state of the heart in the fœtus, it is evident that when the blood enters the left auricle through the pulmonary veins, the right through the venæ cavæ, and that the valves have crossed each other, it is impossible, either at the time of contraction or of dilatation, that the blood should pass through it.

Although the foramen ovale still remains open after birth, the dark blood has ceased to flow through it,—I will say more,—that this foramen may remain free during the whole course of life. Several authors have produced instances of it. I have myself seen a great number, although the assertion may at first appear exaggerated. Now, by the very disposition of its two valves, it is impossible the blood should pass through. When the two auricles contract at the same time, the blood thus propelled inwardly by the auricles applies the valves together, and forms itself the obstacle. In the greater number of instances the adherence of the two valves crossed over each other, is remarkably slight; they are rather attached than continuous; so that, by introducing between them the handle of the scalpel, they are easily separated, and scarcely any signs of laceration remain. If they were disposed in such a manner that the blood might filtrate, they would soon separate, and the communication would be re-established.

Let authors, then, give themselves no further trouble in seeking to explain how life can be continued whenever the foramen ovale has remained free: it is as though it did not exist; the blood will no more flow through it in one instance than in the other.

The obliteration of this foramen, the blood ceasing to flow through it, are, as we may see, phenomena in some degree mechanical.

The laws of vitality also are not inactive on this occasion. Who can tell if the sensibility of the auricle, stimulated and recently modified by the red blood, does not repel the black that tended to enter it through the foramen? Every day we see in the economy fluids cross apertures without entering them, although these remain open, and for this reason only, that their sensibility is not connected with such fluids. Why does the trachea convulsively reject every fluid and solid? How happens it that air only is admitted? Why is the blood never seen to enter the thoracic duct, which in many cases is only provided with a valve, that is not sufficient to impede its course, and sometimes does not exist? Why does the ureter repel urine in the venereal organs? It has been the fault of all authors to seek only for mechanical causes in the phenomena of circulation. Undoubtedly, the course of the blood is a mechanical phenomenon, but the laws that govern it are vital: it is like a bone moved by muscular contraction; the effect is produced by the mechanism of the lever, but the cause is vital.

The blood having ceased to flow through the arterial duct, this soon diminishes from the contractility of its texture; it becomes a kind of ligament, that maintains the aorta and pulmonary arteries in their respective positions.

In regard to the obliteration of the foramen ovale, it is not governed by this property; it is not produced by contraction, but by an actual agglutination of the two valves, between which, at the time of birth, it is obliquely situate. This agglutination seems to proceed from the contrary pressure of the blood contained in each auricle, on the partition common to both. In fact, the fibres of the auricle are so disposed as to contract from without. Now, by this contraction, the blood on each side is pressed against this partition, and, consequently, the two valves against each other. Besides this agglutination may always exist, whilst the contractility of texture, never failing to act when the parts it animates have ceased to be distended, the arterial duct is constantly obliterated.

At the same time that the ductus arteriosus and the foramen ovale have ceased at the moment of birth to transmit the blood, this fluid no longer circulates through the umbilical artery and vein.

Why has the blood ceased to flow through that artery, although its diameter at birth is still considerable?

The chief cause appears to me to consist in the nature of the red blood, which is no longer connected with the sensibility of that artery. A proof is, that, after the respiration ceases for a time, after having taken place, and the blood has again become dark, the umbilical arteries will begin to beat again, and if the ligature be loosened, a considerable hemorrhage will ensue. Baudelocque has repeatedly seen this occur.

In general, whenever respiration is properly performed, the blood ceases to flow through the umbilical artery, and, in this respect, the ligature might be dispensed with. On the contrary, as long as this function remains imperfect, the hemorrhage of the artery is to be dreaded. I readily grant, however, that other causes might exist for this interruption in the course of the red blood. The four following cases—1st. The absence of the blood in the umbilical vein ceasing to take place. 2nd. The interruption of the course of that in the vena cava inferior, through the foramen ovale. 3rd. The cessation of the circulation of the pulmonary artery through the arterial canal. 4th. Of the blood of the aorta descendens, in the umbilical artery. These four circumstances, I say, particularly the three last, seem to proceed from a cause with which we are not yet well acquainted. The change that takes place in the connection between organic sensibility, and the nature of the blood, might be only accessory; since, as I have already stated, it is not so much this property, as it is the action of the heart itself, that performs circulation in the trunks. This subject claims, in a particular manner, the attention of physiologists.

When once respiration is fully established, the lungs are found in a state of opposition to the whole body; they distribute the blood to all parts of the body, and from these this fluid is returned. Then there is a very obvious distinction between the two systems of the red and of the dark blood, and things are carried on as we have before stated.

Subsequent to birth, the vascular system of the red blood, on account of its greater developement and its more numerous ramifications, still predominates for a considerable time. In fact, the number of vessels penetrated by red blood, is greater at this epoch than afterwards. It is only necessary to dissect the bodies of different animals, to be convinced that the system in question contains, in the early periods of life, a much greater quantity of blood; so that, as I have before stated, the two extreme stages of life, present, in respect to the fluids and solids, quite an opposite disposition. The former are so much the more abundant as we draw nearer to the moment of conception. The latter are gradually increased as age advances. The predominance of the system of the red blood is obvious, till the cessation of growth. The necessity of such predominance to distribute to all the parts the substances for their nutrition and increase, is easily conceived. In fact, in the adult, the arteries contain only what is intended for the first process; in the infant they convey also what is indispensable to the second. This unavoidably requires that the calibre of the arteries should be proportionally larger than afterwards, to contain a greater quantity of blood. It is, in fact, demonstrated by injections; and in this respect young subjects are as fit for the study of the arteries as for that of the nerves; in these the vessels are more predominant, only the neighbouring parts being less developed, the connections cannot be so readily ascertained.

In proportion as the infant increases in age, an equilibrium in the system of the red blood is gradually established. In the head, the arteries of the face become more striking, and with regard to their developement, are placed by degrees on a level with the cerebral arteries. In the chest, the thymus gland decreases progressively as the lungs increase, the nutritive arteries of each follow a reverse order; the bronchials dilate, whilst the former contract. In the abdomen, a less quantity of blood is conveyed to the capsular arteries; but the greater part of the others receive a similar quantity. The pelvis and lower extremities receive more, and their increase is great in proportion.

SECTION III.

State of the Vascular System of the Red Blood after Growth.

It is towards the age of puberty that the increase in stature generally subsides; the increase of bulk still continues. The organs of generation, hitherto neglected, seem, at this stage of life, to become a focus of vitality more active than that in the greatest part of the other organs. The portion of the system of the red blood that belongs to it is then increased. The first effect resulting from this, is the secretion of semen, and a general impulse in every individual directed towards wants and desires quite new to him, particularly towards those relating to the propagation of the species.

Another phenomenon soon follows upon this: The lungs are connected with the genital parts by an intimate tie, although unknown to us; they experience the predominance of these parts. Their vital energy also increases, and then begins the time for the affections to which this viscus is liable. Then, such cause as might produce in the adult a gastric affection, now acts upon the lungs.

It is, in reality, only towards this period, that the predominance of the superior parts, of the head especially, ceases. Thus, whilst the nostrils in the infant are the frequent seat of hemorrhage, in the youth this affection is more commonly in the lungs. The increase of energy in the lungs, which is immediately subsequent to puberty, might be considered as the epoch, when the predominance of the superior parts subsides. The cutaneous eruptions of the scalp, the tinea capitis, and the various kinds of incrustations are less frequently met with; convulsions, and the whole series of diseases that proceed from the excessive susceptibility of the brain become also less frequent, and appear to have given place to the numerous list of acute pulmonary affections.

It is towards this epoch, that is to say, a short time after the increase in stature has ceased, that such diseases as are considered to be produced by arterial plethora begin to be conspicuous: this is, as it were, their period, which arises from the following cause. As before the age of puberty, the blood contained not only the substances intended for nutrition, but also those for growth, so long as this continues the whole is expended in the system of the red blood. But when the parts have attained their full extent, and this system still continues to receive the supply intended for growth, real arterial plethora must necessarily be the consequence. It seldom happens, that towards the end of the period when growth ceases, some affection arising from plethora does not take place; this, however, is regulated by the influence of constitution, by the previous mode of living, the seasons, &c., and by numerous other causes, which varying the phenomena of the animal economy, seldom admit of general principles being set forth in an exclusive manner. Thus, all we have stated regarding the pre-disposition to several diseases, in the different stages of life, &c., admits, consequently, of numberless exceptions.

By degrees, this predominance of the lungs is lost; an equilibrium is established in all the organs, each of which, till then, had in turn, taken a more or less important part in the phenomena, relative to the different stages of life. As the system of the red blood is constantly met with in all parts in proportion to their increase, to which it especially contributes, the equilibrium for this reason takes place at the age of twenty-six or thirty years; all the arteries have then acquired a proportional dimension, which is subsequently maintained, whilst, till that period one or other division predominated in consequence of the disproportionate increase of the organs to which they resort.

Towards the fortieth year, the gastric viscera seem to acquire a more marked vitality; but this vitality does not influence the volume of the arteries that are distributed to them.

Although the increase in height ceases about the sixteenth or seventeenth year, the increase in width still continues, so that the internal viscera continue to enlarge, and their arteries consequently expand till this mode of increase also terminates. I have constantly been struck with this phenomenon, on comparing the injected arteries in a subject of sixteen or twenty years old, with those of thirty-six or forty. In the latter, they are constantly much larger. This is the distinction that suggested to me the first idea of distinguishing the increase in the length, from that in the width of the body, because the developement of the arteries invariably implies a corresponding state of the organs. The period when the body ceases to increase in width is then very remarkable—1st. For the want of increase in the calibre of the arteries. 2ndly. For the general equilibrium which takes place in their developement.

In proportion as arteries increase during the years succeeding to the growth of the whole body, their density and thickness is augmented, their fibres become more and more evident, their elasticity is augmented, their suppleness decreased. This explains why the age of manhood is that in which aneurisms are most frequent: it may be remarked, that the density of arteries augments in the same proportion as the fleshy fibres of the heart: so that the more the power of this organ is increased, the better are the arteries capable of opposing resistance.

SECTION IV.

State of the Vascular System of the Red Blood during Old Age.

In the latter years, the system of the red blood is remarkable for the following phenomena.

The number of the arterial ramifications is considerably diminished. In proportion as the heart loses its energy, it propels less blood, and with less force. The general vibration it produced in the whole arterial tree is less sensible at its termination. The minute vessels that formed the extremities gradually contract, obliterate, and are converted into as many small ligaments. This is the reason why, when the periosteum is removed from the bone, the dura-mater from the interior surface of the cranium, scarcely any blood escapes; why the skin wrinkled, and hardened as it were, exhibits no longer the rosy hue, previously observed, especially in youth; why the section of the bone hardly produces any blood, whilst it was so very abundant with the fœtus: why the mucous surfaces fade, and muscles become tarnished, &c. Every anatomist is aware that injections are less perfect in proportion as the subject is more advanced in years; that in extreme old age, the trunks only will fill; that the fluid never penetrates into the ramifications. In small subjects it is quite the contrary; that even the coarsest injections will penetrate these vessels in such a manner, that dissection is attended with difficulty. I have dissected several old animals, when alive, and the small quantity of blood contained in the minute vessels, compared to what is observed in those of the young subject, was very remarkable. The general position I have already set forth, namely, that solids tend progressively to predominate, is strictly correct; this obliteration of the small vessels is remarkable even in the parieties of large arteries; it is observed in the dead body; I have ascertained it in the living subject.

The diminished quantity of the red blood in old age, relates particularly to nutrition, which in the infant is comparatively nothing. It may also be remarked, that in addition to the absence of power in the motion that animates the blood, it is also the cause why there is so little excitements throughout the body in advanced age. In fact, circulation is not only intended to convey to the different parts, the materials for secretion, exhalation, nutrition, &c., we shall also perceive, that it maintains them in an habitual state of excitement by the shock it communicates, the source of which is evidently seated in the heart. Now this shock evidently proceeds: 1st. From the quantity of fluid. 2ndly. From the degree of force with which it is propelled. In these respects, excitement must gradually decrease as age advances. All the functions of the child, either organic or animal, are characterized by a degree of vivacity, a kind of impetuosity, quite at variance with the slowness and want of energy attending every motion in old age.

In proportion as age increases the arterial texture becomes condensed, the lamina formed by the fibres becomes dryer, and barren even, if I may be allowed the expression.

I have stated that the internal membrane is frequently the seat of a peculiar ossification, which hardly ever influences circulation, unless it takes place in the origin of the aorta.

Arteries do not dilate in old age; the arch of the aorta generally experiences a dilatation, which is more or less considerable, and which being always affected without laceration of the fibres, naturally implies, that these fibres are possessed of extensibility: this undoubtedly depends upon the habitual and direct impulse of the blood, against the concavity of the curve. I have frequently sought for similar dilatations in those parts of the arteries where the curvature is most remarkable, in the internal carotid for instance, when it enters the bony canal, but could never perceive any.

In old age the pulse is remarkably slow: a circumstance quite the reverse of that in infancy, when the blood moves with very great rapidity. These two facts completely opposed to each other, are, from what we have stated, nearly unconnected with arteries: they merely denote the degree of force which the heart, the general impulsive agent of the red blood, is possessed of.

It is the same in respect to pulsation in the last moments of life; it is no longer a real beating of the artery, it is a kind of undulation of feeble oscillatory motion, which is the more obscure as life declines. Now, I have ascertained by an experiment easily performed, that the heart is the only cause of this undulation, it is this. I have laid bare in several dogs, on one part the carotid artery, on the other the heart, by a section of one side of the chest, performed in such a manner that respiration might still be maintained by the other. By placing the finger on the artery, I noticed that as long as the heart continued its natural beat, pulsation took place as usual, that it was even rather accelerated, because by the contact of air, the contractions of the heart were increased, but after that time, its motions began to weaken, then it contracted by a kind of general quivering of its fibres. In proportion then, as the contractions of the heart became weaker, the pulse continued to sink: as soon as the tremulous motion invaded its fibres, the beating of the artery was converted into that peculiar undulation, which indicates that every kind of motion will soon cease.

I shall observe, in the system of the muscles of organic life, that the heart is possessed of several modes of contraction, the most remarkable are: 1st. That it is naturally endowed with, in which contraction and dilatation suddenly and regularly succeed each other. 2ndly. That in which these two motions having remained in their natural state are irregularly connected. 3dly. Those in which the fibres only oscillate, by which the cardiac cavities not being sufficiently contracted, impart to the blood an undulatory motion, rather than a perfect shock, &c. Now, to every kind of motion of the heart, a peculiar kind of pulse corresponds, which is easily ascertained in living animals.

I am surprised that authors who have argued so much upon the causes of this phenomenon have never thought of resorting to experiments to decide the question. There are, no doubt, numerous modifications of the pulse, which it would have been impossible for them to connect with the motions of the heart; but the slow and quick pulse, the strong and the feeble, the intermittent, the undulatory, &c., by laying the heart bare, and by placing at the same time the finger on an artery, will be instantly conceived. During the short moments preceding death, we shall constantly find, that, whatever may be the changes of the pulse, there is always something analogous in the motion of the heart, which undoubtedly would not be the case if pulsation depended especially upon the vital contraction of the arteries. I have had frequent opportunities of repeating these experiments, either directly for this purpose, or with other views; but I have never seen the motions of the heart at variance with that of arteries. In general, the theory of the pulse requires, as I have said before, new researches; but I have accumulated a sufficient number of facts on this head to ascertain that the varieties it experiences, according to the different ages, and under other circumstances, depend almost exclusively upon the heart, which, in particular, produces that kind of undulation, or oscillatory movement, which is intermediate to the pulsation of the natural state, and the entire loss of motion.

SECTION V.

Accidental Developement of the System of the Red Blood.

I shall speak (when treating of the organic muscles) of the accidental enlargement of the left side of the heart. As to arteries, new ones are never formed; but in numerous instances those which exist admit of a very considerable increase, arising from two causes:—1st. From an obstruction in the course of the blood. 2nd. From the production of some tumour.

1st. The dilatation of arteries from obstructed circulation, is shown by the tying of arteries in aneurism, and in the spontaneous cure of aneurisms, a phenomenon of which a tolerable number of cases have within a few years been published. Sometimes the great collateral trunks are enlarged; on other occasions, their diameter undergoes no change, and it is through the ramifications that communications are effected. Whenever the branches are dilated, the thickness of their parieties increases, in proportion to the diameter; at least, I have twice ascertained this fact, which is analogous to that presented by the left ventricle when affected with aneurism.

2nd. Every tumour does not produce a dilatation of the arteries: this dilatation is seen in cancers, as in those of the breast, of the uterus, &c., in the osteo sarcomatous tumours, spina bifida, in the divers funguses, &c.

In general, the greater part of tumours that are attended with excessive pain, present this phenomenon. One might, even frequently, be induced to say, that pain in a part is sufficient to produce a determination of blood, and to dilate the arteries. We are well aware that, in the operation of the stone, whenever the subject has previously laboured under severe pain, the hemorrhage is frequently the more to be dreaded.

I have never observed, subsequent to abundant and long-continued secretions or exhalations, that arteries were more dilated in the glands or round the exhaling organs. Whatever may be the size of the cysts, their parieties never contain arteries proportioned to those developed in the midst of cancerous tumours.

The cerebral arteries, in cases of hydrocephalus; those of the mediastinum, the intercostals, &c. in hydrothorax; the mesenteric, the lombar, the stomachic, the epigastric, &c. in ascites; the spermatics, in hydrocele; the renals, in diabetes; the branches which project to the parotid glands, subsequent to long-continued salivation; all preserve their natural dimensions, and are even reduced under some circumstances.

When arteries are dilated in tumours, do their parieties, as in the preceding instance, acquire a proportionate thickness?

I have nothing to state in this respect.

SOCIETY

VASCULAR SYSTEM

OF

THE DARK BLOOD.

The red blood circulates in one single system, in the branches of which it every where communicates; the dark blood, on the contrary, is contained in two systems, separated from each other, and having between them nothing in common but their form: these are, 1st. The general system. 2nd. The abdominal. The first will now come under consideration; the second will be noticed afterwards.

The general vascular system of the dark blood arises, as we shall perceive, from the whole grand capillary system; it accumulates towards the heart, in large trunks, and is lost in the capillary vessels of the lungs. As that side of the heart, belonging to it, will be subsequently examined, and the pulmonary artery in its proper membrane has a striking analogy with that of the other arteries, the veins now claim our attention; but we shall first take a general view of the common membrane, which is extended through the whole system of the dark blood.

ARTICLE I.

Situation, Form, Division, General Disposition of the Vascular System of the Black Blood.

We shall now consider the veins in the same manner as we have examined the arteries, in their origin, their course, and termination, with this distinction only, that we shall follow them inversely, in order to accommodate the ideas we are about to form of them, to the course of the blood that circulates in their cavities.

SECTION I.

The Origin of Veins.

This origin proceeds from the general capillary system. I shall describe, when viewing that system, in what manner they are continued with the arteries. Here I shall only remark, that these vessels never arise from any organ into which arteries do not penetrate; such as the tendons, cartilages, hair, &c., which evidently proves, that blood cannot be formed without the general capillary system. In this system the fluid leaves the principles, from which it received its reddish hue; probably borrows others: in a word, it is therein modified, but never produced.

The egress of the veins from this system is not so easily distinguished as the entrance of the minute arteries, because the valves prevent injections penetrating so far into these vessels. In subjects killed by asphyxia, apoplexy, &c., the ramifications of the veins are more readily ascertained. In these subjects they are seen to divide soon into two kinds: some attend the last arteries, the others are distinct from them.

In the greatest number of our organs, the trunks of the veins pass out at the same part where the arteries penetrate. This rule, however, admits of some exceptions; in the brain, for instance, the arteries enter it below, the veins pass out from above. In the liver, the one penetrates into the inferior part, the other escapes from behind, &c. In general, this circumstance is immaterial to circulation, which is performed in the same manner, whatever may be the connections between the arteries and the veins. In those parts where the arteries enter and the veins pass out, more or less cellular texture sometimes serves to unite the small vessels that are in juxta-position, at other times a more or less extensive space separates them, as in the muscles, nerves, &c.

Besides the origin of veins corresponding to the terminations of arteries, there is a class of veins that separates from the arteries at their exit from the general capillary system. This class is particularly remarkable in the external parts of the body. Every organ so situate, is seen to produce,—1st. Veins that resort to the internal parts to attend the arteries; others that proceed externally, become sub-cutaneous, and form trunks that will presently be noticed. In several internal organs, the same division of veins is observed.

From this general disposition, it follows that the veins arising from the capillary system, are more numerous than the arteries that proceed to it. This is the principle of the disproportion in the capacity existing between the system of the red blood, and that of the black, a disproportion that will afterwards be considered.

Veins frequently communicate in their origin; a number of minute patches, proceeding from their intermixture, are seen in parts that will admit of their being perceived, as under the serous surfaces, &c.

SECTION II.

Course of the Veins.

On issuing from the general capillary system, as we have just stated, veins take different directions. 1st. In the limbs and in the external organs of the body, they are continued in two sets, the one internal that attends the arteries; the other external, which is the sub-cutaneous. 2dly. In the internal organs a similar observation is frequently made: Thus, there are superficial veins for the loins, and deep veins accompanying the arteries. All these, however, are often united to those which attend the artery.

The cutaneous division of the veins is very remarkable in the extremities, where it displays considerable branches; namely, the saphenæ in the inferior; the cephalic, the basilic, and their numerous divisions in the superior extremities. In the trunk and in the head, such a considerable number of sub-cutaneous branches are not observed, except in the neck, where the external jugular vein is seen; but there are a number of branches smaller in proportion to the ramifications that resort to these parts.

The external parts are then remarkable for the predominance of trunks carrying dark blood over those of the red. Frequently their course is seen through the integuments, and so much the more as these are whiter and of a finer texture; in other respects, however, they are not connected with those which proceed entirely from the blood contained in the capillary system.

Within the body, the veins accompany the arteries in almost every part; they follow the very same distribution; so that they are not commonly described, because the course followed by arteries is sufficient to trace theirs. In general, a cellular space common to all, receives both the trunks of these two species of vessels, and those of the nerves. Sometimes, however, veins are found quite insulated, as the azygos, for instance, which has no corresponding arterial trunk, and which, on this account, like the superficial veins of the trunk and extremities, requires, in descriptive anatomy, a special investigation and a minute dissection to convey a correct idea of them.

SECTION III.

Proportion of Capacity between the two Systems of the Dark and the Red Blood.

In consequence of the observations I have just made, respecting the origin and the course of the veins, it is evident that, considered as a whole, they are much more capacious than the arteries. This assertion will be easily verified by examining them individually, in parts that are conjoined, as in the loins, the spleen, in the limbs, &c.: even in those parts where the veins are separated from the arteries, as in the brain, the liver, &c. this is not striking. Finally, there is also, as I have just said, a sub-cutaneous division of veins, which is evidently greater than the arteries.

Several physiologists have attempted to calculate the degree of capacity between the veinous and arterial systems; but this is evidently too variable to be ever established. In fact, to make the dead body the subject of this experiment would be useless; for, according to the manner in which death has been occasioned, the veins will be found more or less dilated. In apoplexy, asphyxia, submersion, &c. the diameter of these vessels is double, compared with what they present when the subject has died from hemorrhage, because, in the former mode of death, a great quantity of blood is accumulated in the veins, and in the latter they are drained of this fluid. We can produce a greater or less capacity in the veins of an animal, according to the method employed for its destruction, and for the same reason we can increase or diminish at will the right cavities of the heart, by making use of the same means. I deny that the veins can ever be found exactly equal in two different subjects, let their uniformity in respect to stature, age, &c. be what it may. If a living animal be selected for this purpose, besides the great difficulty it would be attended with, still no uniform result in this respect would be obtained, because the diameter of the veins varies in consequence of their being more or less filled. If we observe these vessels in subjects in which they may be perceived through the transparency of the integuments, they are sometimes more apparent than at others. Their volume is alternately doubled or rendered scarcely perceptible. There can be no doubt, that after copious drinking, when the dark blood has received a considerable supply of fluid, the vessels are more dilated than they are in the reverse state. Veins are remarkably contracted in subjects that have died of hunger. I have frequently observed the same phenomenon in cases of dropsies, consumptions, declines, &c. In general, whenever the mass of blood has been lessened, the veins are reduced by the contractility of texture. Arteries, on account of their firmness and tightness of tissue, are less subject than the veins to these variations, but still they afford frequent instances of it.

Let us then throw aside all calculation in respect to the proportions of capacity in organized canals. Whatever is permanent and invariable only can be admitted; but whatever varies at every instant can only be an object of general assertion. Besides, where is the advantage of ascertaining the strict proportions, that a number of physicians have attempted to establish between our parts? they are useless in respect to the explanation of the phenomena concerning health and diseases. Let us then be satisfied with this general assertion, that the capacity of the veins surpasses that of the arteries. It may then be said, that in a given time the one contains more fluid than the others.

The same observation may in general be applied to the two sides of the heart, one of which is joined to the veinous system, the other to that of the arteries. The right side is generally larger than the left, not exactly in respect to the fleshy texture, but to the fluid that distends it; this is so correct, that if in an animal whose chest is laid open, the blood, by means of ligatures, be confined in the left side, and the right be emptied by making a few punctures, it will be reduced to a less volume than the other. Whenever in the dead body it has been found larger than the other, it was because, with the exception of the diseases of the heart, it contained more blood at the instant of death; in fact, as this fluid generally stops first in the lungs, it reflows into that side of the heart which is commonly the largest.

This is the essential distinction between the inert cavities and those endowed with life, namely, that these at every moment can vary their capacity, whilst the others ever remain in the same state. In the living subject the right side of the heart is almost in every instance larger than the left, because it contains a greater quantity of blood.

Here then are two facts generally applicable, namely; 1st. That the great tree which terminates the system of the red blood, is in general less in capacity than that which forms the commencement of the other; 2dly. That the same observation is applicable to the two sides of the heart, corresponding to each of those trees.

In respect to the tree which terminates the system of the dark blood, when compared with that beginning the system of the red, it is not exactly the same. The pulmonary artery, and the veins of that denomination, present a disproportion in capacity less, it is true, than in the other parts, but really existing; and which, notwithstanding what several authors have set forth, is to the advantage of the latter. How does this happen? It seems that since the one is a continuation of the veins, that it propels the same fluid, it ought to partake of the same proportions in diameter, and that since the others are continued with the arteries, their capacity should also be in a relative proportion to these. This arises from the degree of rapidity with which the blood flows: in fact, this fluid circulates more rapidly in the pulmonary artery than in the veins of the same denomination, since it is provided with the impulse of the heart, of which these are destitute, so that in a limited space of time the same quantity of fluid circulates through this artery, although its diameter is more reduced. Nay, if the diameter were the same, circulation could not take place; in the same manner, if the size of the aorta were equal to that of the venæ cavæ and coronaries united together, and the fluid retained the same degree of rapidity, circulation could not exist.

The union of the pulmonary veins forms a wider trunk than that of the aorta, which, however, transmits the whole quantity of blood conveyed to them. What is the reason? Because the impulse given by the left ventricle, causes more fluid to flow through the aorta in a limited space of time, than through the four pulmonary veins. The following circumstances, 1st. The rapidity of the fluid. 2dly. The capacity of the cavities through which it flows, are then reversed in the two trees opposed to each other, each forming a vascular system. In that of the red blood, there is less rapidity, and more capacity, from the capillary system of the lungs to the heart; from this organ down to the general capillary system, there is, on the contrary, more rapidity and less capacity. In the system of the dark blood, the motion is more gentle, and the space is greater from the general capillary system to the heart; from this organ to the pulmonary capillary system, there is more rapidity and less space. Without these reverse dispositions, it is evident that circulation could not exist.

In this respect, however, an essential remark ought to be made; it is that the capacity of the four pulmonary veins taken together, far less exceeds that of the aorta, than the two vena cava and the coronaries exceed in diameter the pulmonary artery. I account for this as follows:—On the one part as the pulmonary veins have to pass but a short distance, the impulse which the red blood has received from the capillary system of the lungs, is longer continued; on the other part, this fluid is not exposed to the numerous causes of delay to which the blood of the venæ cavæ and the coronaries is liable; then the rapidity must be greater and the capacity less. If the lungs were situate in the pelvis, the pulmonary veins would undoubtedly be more spacious, because the blood, having a longer distance to overrun, its motion would be more retarded.

We may now easily conceive the cause of several circumstances that have given so much labour to a number of anatomists; namely, 1st. Why the sum total of the arteries proceeding from the aorta, is less in capacity than that of the veins resorting to the right auricle. 2dly. Why the four pulmonary veins also exceed, in diameter, the pulmonary artery. 3dly. Why these four veins are not exactly proportioned to the aorta, although it is the actual continuation of them. 4thly. Why the venæ cavæ and coronaries are so disproportionate with the pulmonary artery, which is a continuation of them?

If there existed no impulsive agent in the two systems of the arterial and veinous circulations, their respective capacities would prove every where nearly the same, because the rapidity of the fluid would be every where alike. This is precisely the case in the system of the dark abdominal blood, in which the hepatic part of the vena porta is nearly as large as the intestinal, because there exists no heart intermediate to them.

In the general and pulmonary veins, circulation is slower, because their extremity is not provided with an impulsive agent; there is only a capillary system. The opposite reason accounts for the rapidity of circulation in the general and pulmonary arteries. We have found in the preceding system, that the existence of an impulsive agent at the origin of the two great arteries, requires a remarkable degree of resistance in this tissue, whilst the want of this organ requires from the veins but little resistance.

We can now very easily conceive why these three facts, 1st. Weakness in the parieties; 2dly. Slowness in the motion; 3dly. Extensive capacity, are within the attributes of the veins in both circulations;—why these three reverse ones; 1st. Strength in the parieties; 2dly. Rapidity of motion; 3dly. A reduced capacity essentially characterize the arteries of the two vascular systems.

From this we may also conceive why, although the veinous and arterial circulations form in their whole extent but one continued column, and although the common membrane in which they move, is throughout both systems nearly the same, yet the organs superadded to this membrane are very different.

The reverse connection, between the acceleration and the capacity of the vessels, appears to me so very evident, that, from the inspection of a vessel, the degree of rapidity with which the fluid circulates through it, might nearly be ascertained, if numerous causes did not at the time of death occasion numberless variations in the vascular parieties. It is well known, that every cause, which lessens in the veins the rapidity of the blood, increases their capacity: thus it is that ligatures serve to increase them; that pregnancy enlarges those of the lower regions; that a fixed posture continued for some time will produce the same effect, &c.

The following phenomenon must also be referred to the very same cause; namely, that the connection between the arteries and the veins is not every where the same; thus, the renal bronchial veins, those of the thymus gland, &c. are generally less voluminous in proportion to their arteries than the veins of the spermatic cord are to the artery of that name, or than the hypogastric vein when compared with the corresponding artery : the blood circulates with more facility in the former than in the latter, in which it ascends contrary to gravity ; this again explains why the veins, in the inferior parts, especially at a certain age, exceed in a greater degree their arteries in diameter than those of the superior parts are seen to exceed theirs.

Ramifications, Branches, Angles of Re-union, &c.

The veins with respect to branches and ramifications of every description, present in their course a disposition analogous to that of the arteries, with this distinction only, that it exists in a reverse sense. The ramifications are the nearest to the origin; they soon unite into small branches, which form larger ones, and these again are united into trunks.

The ramifications and the greatest part of the smaller branches are situate within the organs. The former are amongst the constituent parts of these organs, and are found amongst their fibres, &c. The latter are lodged in the large interstices—in the glands, amongst the lobes; in the brain, amongst the circumvolutions; in the muscles, amongst the fasciculi, &c.

On issuing from the organs the ramifications of the veins plunge into the branches, which assume, as we have observed, two positions, the one sub-cutaneous, the other deep. The sub-cutaneous branches ramify in the limbs, between the aponeurosis and the skin; in the trunk, between this and the abundant cellular layer, that incloses the muscles. The deep-seated branches are situate in the interstices of the organs, and attend the arteries in almost every part.

The cerebral branches have a particular distribution; they are situate in the interstices of the dura-mater, and in common with these interstices, they form what is called the sinuses.

The branches of the veins differ from those of the arteries, in being infinitely less flexible: this is remarkable both under the skin and in the interstices of the organs. This would prevent locomotion, admitting that an impulsive agent existed at the origin of the veins, and that their parieties were not of so lax a nature. It therefore follows, that a continuation of arterial tubes is actually more extensive than a corresponding continuation of veinous tubes; this facilitates the motion of the dark blood, which has less distance to overrun, and would find in the flexures causes of obstruction, which in respect to the red blood, would have no effect, because it is directed by a powerful impulsive agent, with which the veins are not provided.

The branches of veins unite to form a certain number of trunks that join those directly intended to pour the fluid into the right auricle; these trunks are the internal jugulars, the iliacs, the azygos, the subclavians, &c. They are still less curved than the branches; like the arterial trunks they are deeply situate; distant from exterior injury, from which they are secured by a number of organs, because their hemorrhage might be attended with the most fatal consequences.

The trunks, branches, divisions, and ramifications do not always necessarily arise from each other in the manner we have described. The smaller branches frequently unite with the trunks, the ramifications with the branches, &c. as occurs in the arteries.

The angles of union vary: sometimes they are right angles, as those of the lombar and renal veins, &c.; at other times they are obtuse, as those of the intercostals; most generally they are acute.

The disposition of the small and large branches varies in the veins, at least as often as in the arteries; they partake in this respect, of that characteristic irregularity peculiar to the organs of internal life. Thus, the general position and the distribution of the branches, &c. only should be attended to; in respect to their union with the trunks, there are nearly as many distinctions as subjects.

Forms of the Veins.

The same observation in respect to the forms of arteries, is applicable to the veins.

1st. A trunk, a branch, &c. is cylindrical, when a part which receives no small branches is examined. In the dead body they seem compressed; this proceeds from the fall of the parieties, from the absence of blood, but on being expanded, either by injection or inflation, &c. they re-assume their primitive shape. In the living subject, they appear circular.

2ndly. When viewed in some considerable extent, a branch of the veins appears of a conical figure, with the basis directed towards the heart, and the summit towards the general capillary system. This form proceeds from the successive addition of smaller branches, which gradually increase its capacity as it approaches the heart.

3dly. Considered as a whole, the veinous system represents three trunks, two of which correspond to the superior and inferior venæ cavæ, the third to the coronary vein: the summit of these three trunks answers to the auricle, and the basis rests in the general capillary system. Anatomists have thus figured to themselves the assemblage of the veins, because, as in the arteries, the capacity of the sum total of their divisions is greater than that of the trunks.

In this respect, however, an observation ought to be made; it is, that in veins the connection between the trunks and their divisions in the veins is never so very exact as it is in the arteries. Thus, the sum total of some divisions greatly exceed their trunks, whilst this connection is far inferior in other instances. But all this again depends upon the excessive variations of the veinous coats, according to the quantity of fluid they contain; thus, in the dead body, in some instances, the branches are found excessively dilated by the blood, the trunks remaining in their natural state, whilst on other occasions it is quite the reverse.

1st. This last especially takes place when the lungs are affected; in this case, the blood re-flows in the right cavities of the heart, and from thence into the large corresponding trunks of the veins; these are in such cases found almost to equal, or even to exceed the divisions they sometimes furnish. 2ndly. When in the living subject a limb has been kept for some length of time in a perpendicular direction, then the branches become more dilated than the trunks; but as these causes of dilatation vary considerably, such dilatations must also vary.

From such variations in the separate dilatations of the branches and trunks of the veins, it is evident that the connection existing between them is remarkably visible, that it is subordinate to the mode of death, to the diseases that have preceded, to the habits of the subject, &c. Let us then, on this point, as well as on all others, lay calculations aside, which even if founded on solid grounds could answer no useful purpose.

Injections are also deceitful when used to ascertain this connection; in fact, they dilate the trunks much more than the branches, and these more particularly than the ramifications. The internal jugular vein for instance, when injected acquires almost an enormous size, when compared with the sinuses that empty into it. The venæ cavæ, the azygos vein, the subclavian, &c. are rather less dilated than the jugular, but their volume becomes very remarkable on injection, when compared with that of their injected branches.

Anastomosis.

In general, veins communicate more frequently than arteries. 1st. In the ramifications, anastomosis is so multiplied as to form a perfect network. 2ndly. They are not so numerous in the smaller branches. 3dly. In the branches they are still less numerous, although in considerable quantity, and it is this which particularly distinguishes the branches of the veins from those of the arteries, which are nearly always separate from each other. The communications between the branches of the veins first unite in a conspicuous manner their cutaneous with the internal division. Thus there is a communication between the cerebral sinuses, and the temporal and occipital veins, &c. by the veins that are given off; between the internal and external jugulars by one and even two considerable trunks; between the basilic, the cephalic veins, and their numerous divisions, displayed in the fore arm on one part, and with the brachial, the radial, and cubital on the other, by different branches that plunge into the muscles between the saphenæ and the crurals, tibial, peroneal, and by similar branches.

Although separated from each other, the two grand divisions of the veins are then enabled to act as respective substitutes, by uniting their blood. This explains why; 1st. By agitating the muscles of the fore arm, the current is increased in bleeding, although the muscles do not furnish many original branches to the punctured vein, which then receives the fluid from those which are compressed by the muscles; 2dly. Why in external pressure, that impedes and even prevents the motion of the blood in the superficial veins, circulation is continued as usual; why, for instance, if a ligature be long continued on the arm, the superficial veins previously swelled, are gradually emptied by transmitting the fluid to the others; why in our tight bandages for cases of fracture and luxations, the blood, as usual, passes from the veins to the heart, although its superficial circulation is much reduced; 4thly. When a bandage has been tightly applied to the superior part of the leg, and the saphena is injected below, the injection is never seen to extend beyond the bandage, but passes into the crural vein: the internal jugular may be filled in the same manner, by injecting the temporal vein, &c.

The anastomosis between the superficial and the deep veins, is more necessary to man than to any other animal, on account of the clothing by which, according to those in use, the neck, legs, the arms, &c. are exposed to compressions that would otherwise soon prove fatal. It may be said, that from these the possibility of a variety of fashions is founded. In fact, they prove that these fashions are less dangerous than some physicians have pretended; that the danger of apoplexy, from wearing a tight cravat, of varices from the pressure of the garter, is much less than has been stated. When a single trunk of a vein is compressed, the blood proceeds without difficulty to the next; but if the compression has been extended to all those of a limb, the blood will require some considerable time to dilate the anastomosis; before such dilatation can be completely performed, it remains stationary, as it were, in the capillary system,—a state of stagnation that accounts for the temporary flush observed in the arms of females, when too much compressed by a narrow sleeve, or that of the hand and foot, when the bandages of these parts have been too tightly applied.

The mode of anastomosis in veins is very analogous to that of the arteries. Sometimes the small branches anastomose with the trunks, at other times the trunks communicate with each other.

In this last mode; 1st. The communication is formed by a small branch; it is seen between the jugular veins, between the deep and superficial veins of the thigh, of the arm, &c.; 2dly. Two branches are joined at their extremities, forming an arch, of which the mesenteric veins afford an instance; 3dly. Sometimes, instead of a trunk, there is a net work of ramifications, such as that which surrounds the cord of the spermatic vessels.

In general, it may be considered, that in those parts where the blood meets with more obstacles, anastomosis is the most common. This is the reason why the veins that surround the spermatic cord so frequently communicate; why the ramifications of the hypogastric vein that extend to the lower part, form a plexus so intricate as to represent a real net-work, in which the communications are so very numerous, that the course of a given branch cannot possibly be traced. Notwithstanding this, these two parts of the veinous system are frequently the seat of varices; few even are so often found dilated, on account of the difficulty the blood experiences in ascending contrary to gravity.

This leads us to a general consideration respecting the anastomosis of the veinous system; that is to say, to demonstrate how essential it is that such communications should be more frequent in this system than in the arterial. In fact, if we compare the course of the dark blood with that of the red, we shall find that it is liable to be affected by a greater variety of causes.

The dark blood evidently obeys in particular cases the laws of gravity.

1st. When a person remains standing for some length of time, the veins swell, particularly after diseases, when strength is much reduced; this swelling will soon subside if the leg be bent; but will increase if it remain perpendicular.

2nd. In numerous instances, in which the strength is much reduced, circulation cannot be properly performed but when the legs are bent, or kept in an horizontal position. The influence of position over several tumours or ulcers, which affect these limbs, cannot be doubted.

3rd. We are aware, that the first effect of attitude on the head bent backwards, is a giddiness produced by the difficulty the blood meets with in ascending against its own weight.

4th. The valves are particularly intended to counteract the force of gravitation.

Every violent motion communicated to the dark blood, and, independent of gravity, may also disturb its course; thus it happens that, after turning violently in a circular direction, a central motion, as it were, is communicated to the veinous blood of the brain, which, diverting it from its natural destination, and preventing it from being completely returned to the heart, produces a stagnation, and hence the vertigo that is experienced.

It is not only gravity and all other external causes for motion, that influence at every instant that of the blood in the veins; but also internal and external pressures, with a variety of other mechanical causes.

The fluid in arteries, on the contrary, is quite independent of the greatest part of these causes, of gravity in particular, and of the internal motion. Why is this? because such is the rapidity of motion impressed by the heart on the red blood, that the influence of gravity, or of all other analogous causes, is necessarily lost.

Let us make use of a simile. The greater the impulse by which a projectile is forced in an oblique direction, the less will gravity cause it to deviate; here the influence is still less.

If the blood were propelled in empty veins, gravity might in some degree affect its motion in the arteries; but in the sudden shock conveyed to the whole mass of fluid with which they are filled, the effect of which shock is instantly experienced, both in the most distant parts as well as in the origin, it is evident the effect must be null. By the opposite reason, we conceive why it is so effectual in the veins, where there exists no impulsive agent, in which the parieties only, in common with the capillary system, are the sources of motion, and in which, consequently, motion must be slowly performed, &c.

From these considerations it is easy to conceive why arteries and veins display such difference in their branches, with regard to anastomosis, which is as uncommon on the one side as it is frequent on the other.

SECTION III.

Termination of the Veins.

The veins terminate by two principal trunks, the venæ cavæ, superior and inferior; a third might also be added, namely, the coronary vein, which is continued separately to the right auricle;

but as this trunk merely returns the blood from the heart, we shall, in these general considerations, take little notice of it, as well as of those minute veins that pass separately to the same auricle.

Some authors have conceived that the venæ cavæ continued together, forming a single vessel only; but it is easy to perceive how very different are their directions. This distinction is most obvious in the fœtus, since one corresponds to the right auricle, and the other to the left. At the back of the right auricle, there is certainly a kind of continued membrane between them: it is the membrane of the dark blood common to both, and which projects from the inferior to the superior vessel; but in this respect they are not more continuous than the right side of the heart and the pulmonary artery, or the left and the aorta, &c.

In considering the whole of the trunks, and of the branches, as forming a cone, we may then say there exist two large veinous cones, distinct from each other; the one intended for all the parts situate above the diaphragm, the other for those below it.

Then the vena cava ascendens does not always answer to the whole of the arteries that form the aorta, of the same description, which is only intended for the head, neck, and the superior extremities, whilst this appertains also to the chest through the azygos vein.

For the contrary reason, the descending aorta has a much more extensive distribution than the inferior vena cava.

The boundaries of the two cones of the venæ cavæ are situate at the diaphragm. It is in this respect especially, that this muscle may be said to divide the body into two parts. Does not such disposition influence the difference observed, in certain diseases, between the superior and inferior parts? Should not this cause, also, be added to those pointed out when speaking of the fœtus? With regard to this opinion, which I do not consider improbable, nothing has hitherto been advanced.

Although each forms a distinct cone, the venæ cavæ, however, communicate particularly near their common boundaries, that is to say, in the neighbourhood of the diaphragm. The vena azygos is the grand medium of communication; it is well known that its trunk opens into the right renal, the vena cava itself, or into some of the lombar veins, and that the small azygos vein arising from it, also enters the left renal, or in the lombar veins of the same side. This anastomosis is of the utmost importance; physicians have considered it too slightly: it proves that when there is an obstruction in the trunk of the inferior vena cava, a great part of the blood of this trunk may be returned by the superior. Much has been said respecting the compression of this trunk, from obstructions in the liver, producing dropsies; but the numerous dissections that have lately taken place, have left it no longer a matter of doubt that these diseases may arise from any kind of organic affection; that the lungs, the heart, the womb, the spleen, &c. may also in the latter periods of the alteration of their tissue, produce them, and that in this respect, in the greatest number of cases they are merely a symptom with which compression is in no way concerned. 2dly. Even admitting that the liver could compress the vena cava where that vein crosses its posterior surface, it is evident that the anastomosis I have just mentioned would, at least in a great measure, prevent its operation.

Supposing that an obstacle were met with in the vena cava superior, the same anastomosis would undoubtedly answer a similar purpose; but as the vena azygos is inserted at a very short distance from the auricle, the course of the trunk of the vena cava superior is consequently very limited; it is evident that it is especially to obviate such obstructions as may take place in the inferior vena cava, that this anastomosis has been established.

When the blood of this vein thus passes into the superior one, it flows through particular branches, contrary to its natural course. Let us suppose, for instance, that anastomosis exists in the renal, which is most frequently the case, then the blood from the trunk of the vena cava enters by one extremity of this vein, that of the loins by the other. Such a movement evidently implies the absence of valves in the renal vein from the vena cava up to the insertion of the azygos, in fact, the renals never contain any; the capsular, those which supply the fat of the loins, all the lombar veins, are, as Haller has ascertained, equally unprovided with them; and I have constantly ascertained it myself. This want of valves in those parts where the anastomosis of the vena azygos exists, is a very remarkable phenomena, and fully proves the use I ascribed to the communication existing between the vena cava by their means.

ARTICLE II.

Organization of the Vascular System of the Dark Blood.

SECTION I.

Tissue peculiar to this Organization.

THIS organization is nearly the same throughout the whole system; in the membrane forming the great canal in which the dark blood is contained, but it differs from the tissues external to this membrane. In the heart it is fleshy; in the pulmonary artery it is analogous to the tissue in the division of the aorta; in veins it has a peculiar character; this last, especially, will be immediately considered.

Proper Membrane of the Veins.

To view this membrane, 1st. The loose cellular tissue that unites the veins to the adjoining parts; 2dly. The cellular layer of a peculiar nature, which directly covers them, and has been mentioned in the Chapter on the cellular system, should first be removed; then, longitudinal fibres, parallel, and forming a very thin layer, not always perceptible at first, but in every instance existing, are discovered in the large trunks. When veins are considerably dilated, these fibres being more separated, are less striking than in the state of contraction. In the trunk of the inferior vena cava, these longitudinal fibres are more evident than in that of the superior; in general, it may be granted, that they are also more striking in every division of the former than in those of the latter vessel: Of this I have been convinced by numerous dissections. It undoubtedly proceeds from the greater facility with which the blood circulates in the second, than in the first of these veins, where it ascends against its own weight; it is a further proof that man was originally intended for an upright posture.

I have repeatedly made a further remark; it is, that in superficial veins these fibres are much more striking than in those which lay deeper; of this the internal saphena affords a striking instance. A longitudinal incision will show these fibres very distinctly through the common membrane, especially if it be rather contracted. By dividing the femoral vein in a similar manner, the distinction is easily made, a distinction which probably is derived from the assistance which the neighbouring parts give to the circulation in deep seated veins, whilst this is much less useful to those which are more superficial.

The fibres are proportionally more obvious in the smaller branches than in the trunks; from thence proceeds the greater proportionate thickness of their parieties, their more powerful resistance to the action of the blood, their less frequent dilatation, &c.

In those parts where a division projects from a trunk, these fibres alter their course and continue with the division, differing in this respect from the origin of the arterial divisions, whose fibres are not a continuation of those of the trunks.

The veinous fibres often approach, are concentrated, and give a greater degree of thickness to the vein; this is frequently remarked at the origin of the saphenæ. I have also found a similar disposition in the hypogastric veins; it was noticed by Boyer.

In general, the veinous fibre, excepting in these parts, is remarkably scanty, and the membrane it forms is consequently very thin. In this respect, the membrane of the arteries far surpasses that of the veins; it is the very tenuity of these last vessels that especially contributes to their extensibility. Let us observe that the structure of each kind of vessels is calculated for its particular mode of circulation. If the blood were to circulate in veins provided with parieties similar to the arterial walls, at every instant its motion would be disturbed. In fact, numberless causes would produce obstruction in the veinous circulation; whenever the motion is lessened, the capacity is increased, but the arterial textures not admitting of such dilatations, it is evident that circulation could not be maintained, consequently if the impulsive organ situated at the origin of the arteries requires in these vessels a firm tissue, incapable of extension, the slow motion of the blood in veins, and the frequent causes of delay, require an opposite nature in the tissue.

What is the nature of the veinous fibre? Its appearance, its want of elasticity, its great extensibility, the difficulty with which it breaks, its colour, its direction, every thing in short, concurs to distinguish it essentially from the arterial fibre. Is it muscular? it does not seem irritable, as I shall state; its appearance is not the same as that of the muscular fibres. I am inclined to believe it is possessed of a peculiar nature, essentially distinct from that of every other tissue, possessed of peculiar properties of vitality, and organization. I do not believe it capable of much motion. In other respects, however, we have but little information on this head, the veinous fibre, although infinitely more extensible than the arterial, is, however, capable of greater resistance; without lacerating, it will bear a much greater weight, as Wintringham has ascertained in his experiments. In the superficial veins, and those of the lower regions, this resistance is particularly striking. There are numerous varieties in the veinous fibre, according to the individuals in which it exists. In some these fibres are remarkably apparent; in others, they are so disseminated on the large trunks, as to be hardly perceptible; but then, they are always obvious in the branches, particularly in the superficial ones.

There are parts in the veins, in which there are evidently neither external fibres, nor even exterior cellular texture; such especially are, the cerebral sinuses, which present the following disposition. When the jugular vein has reached its receptacle, it is divested of its peculiar tissue, and retains the common membrane only, and plunging into the lateral sinus lines it, and is extended below in the right and inferior longitudinal sinus, above in the superior, &c., and in short, in all those of the dura-mater. Hence, therefore, every sinus implies, 1st. A separation of the lamellæ of the dura-mater. 2ndly. The common membrane of the dark blood lining this separation. It is not then in the dura-mater itself that blood circulates, it is in the very same membrane in which it flows elsewhere; a fact, that is easily ascertained in the superior longitudinal sinus. This is triangular, when considered only in respect to the separation of the lamellæ of the dura-mater; but when opened, it is evidently seen, that the common membrane in crossing over the angles gives them a circular form: this membrane is here very distinct. In several other sinuses, it is easily removed from the dura-mater; but in most cases, it is intimately attached: it is similar to the union of the arachnoïd tunic with the internal surface of the dura-mater. This common membrane of the dark blood opens upon the folds of the superior longitudinal sinus; it forms a very singular net work, which I shall describe, when speaking of the cavernous sinuses.

From this general idea, it is evident that the parieties of the dura-mater serve in the sinuses for the veinous fibres, and the dense cellular tissue with which these fibres are outwardly provided: it is still the same common membrane, but the external tissue is different.

In those parts where each cerebral vein opens into a sinus, the common membrane of this sinus penetrates its tube, and lines it to its most distant parts. I have heard of no author, who had thus considered the cerebral sinuses as presenting the common membrane of the dark blood, extended in the separation of the dura-mater. If the internal surface of a sinus is ever so slightly examined, it is still easily seen, that this surface differs as much from the tissue of the dura-mater as it approaches the appearance of the internal surface of veins.

The cerebral veins that reach the sinuses are, by the excessive tenuity of their parieties, analogous with the arteries in that region; a tenuity apparently proceeding from the absence of the cellular covering, and which is such, that it might induce us to suppose it is only the common membrane.

Circular fibres are never met with in veins.

Common Membrane of the Dark Blood.

This membrane, extended from the general capillary system to that of the lungs, is every where nearly of the same nature, it essentially differs from that of the red circulation in a great variety of particulars.

1st. It admits of much greater extension, consequently is not easily lacerated. If a vein be tied it will not break, unless the constriction has been very considerable; it is nearly as supple as the cellular tunic, a circumstance that renders it more easy to dissect than the common membrane of arteries.

2dly. It appears much thinner than the latter; a proof of which is presented by the valves, which are so thin, that when pressed against the internal surface of the vein, they frequently escape notice.

3dly. This common membrane is never found ossified in the aged subject, as is the case with the arteries; its organization seems not to admit of its being impregnated with calcareous phosphates. Whenever this occurs it is an unnatural state, whilst the ossification of the common membrane of the red blood is in old age, as I have said before, a natural consequence. This difference between the two common membranes of the red blood and the dark blood, gives to the diseases of the heart a distinctive character. Ossification is never seen in the tricuspid valves, nor in the sigmoid valves of the pulmonary artery, whilst it is so very frequent in the left side. This is the constant result of observations made in the Hospital de la Charité; and the dissections of aged subjects have invariably afforded me similar results. The pulmonary artery, although analogous to the aorta in its proper membrane, is never the seat of such ossifications, because its common membrane essentially differs from the other. This single phenomenon, so decisively striking in both of these membranes, would indisputably prove their organic distinctions, as it establishes the necessity of viewing them in a general light, whether it be, that for the dark blood they line the veins, the pulmonary artery and the right side of the heart, or that for the red they extend over the arteries, the left part of the heart and pulmonary veins.

Valves of the Veins.

The common membrane of the dark blood is remarkable for a number of folds called valves. These folds are wanting in the pulmonary artery, except in its origin, where the sigmoid valves are placed; in the heart the tricuspid valves are partly formed by this membrane, but those of the veins are exclusively formed by it. It is these in particular that we are now considering. The form of the valves is a parabolic; the convex edge is adherent, and the farthest from the heart; the other is straight and floats within. Between these and the vein, a space is left similar to that of the sigmoid, aortic, and pulmonic valves. Their free edge is not, like this, provided with a granulation. At that part where they are attached, the veinous tissue is firmer, and provided with a kind of thickening or prominence, forming a line of the same figure as this part of the valve: this protuberance sustains the valves in the same manner as that corresponding to the sigmoidal: it seems to be of the same nature as the veinous tissue, the fibres of which change their direction to form it. When the common membrane has reached this prominent line it folds to form the valve, so that it is apparently formed by two layers, which however are so thin, that they cannot be separated without the utmost difficulty. The veinous valves exist both in the superior and inferior vena cava. In the first, the divisions of the hypogastric, of the crural, of the tibial, of the internal and external saphenæ, &c. are filled with them. The second affords numbers in the external jugular, in the azygos vein, in the facial veins, in those of the arm, &c. Several veins are not provided with valves, as may be observed in the trunk of the inferior vena cava, in the emulgents, in the cerebral sinuses, &c.

The size of the valves is constantly proportioned to that of the trunks where they are found; very considerable in size in the vena azygos, they are less so in the saphenæ, and still smaller in those of the foot, &c. If their extent be compared with the diameter of the trunk they occupy, it will be found that sometimes they can completely obliterate the cavity; at other times they are too narrow to produce that effect. All authors have been struck with this disposition; they conceived it to depend upon original organization; but I have convinced myself that it proceeds solely from the state of dilatation or contraction of the veins. In the first state, the valves being drawn, and even not dilating in proportion, become smaller in respect to the diameter of the veins, whose cavities they cannot, by descending, completely obliterate. In the second state, as they do not contract in proportion to the vessels, they become looser, and are liable to obstruct it entirely.

Whatever, then, authors have written respecting the difference in the size of the valves, it arises solely from the state in which the veins are left at the instant of death. This is so true, that when an animal has died from hemorrhage, they appear wide; on the contrary, they are narrow, if death has been caused by strangulation. I have verified this in two instances.

From what has just been stated it is evident that the reflux of the dark blood is so much more easy, and extends so much further, as the vein is more dilated, that, consequently, the effect of the first ought not to extend further than the second; this still less than the third; and so in succession. It is, in fact, what happens in the case above stated: the reflux never extends as far as the capillary system, particularly in parts distant from the heart, because, having to cross several valves, and each of these partly impeding its course, it loses by degrees the motion it has received from the heart.

The existence of valves is generally constant, but they vary considerably, both in number and situation; sometimes very near, at others times very distant. They display in this respect numberless varieties. In the small trunks they are generally less distant from each other; in the large trunks they are more sparingly distributed. They are seldom disposed three by three, more frequently in pairs, and sometimes insulated, which is particularly the case with small vessels; in those, for instance, of the hand, the foot, &c. Besides, in Haller's book, very long descriptions, regarding the general disposition, the form and position of the vascular folds, we are now considering, will be found.

These folds enact, as we shall see, a very important part in the veinous circulations. It is the existence of these that, in a great part of our operations, supersede the necessity of tying the veinous trunks. In fact, were it not for the valves, the blood poured by the collaterals into the open vessel, might easily pass in a retrograde direction, and the effusion of that contained in the whole course of the vessel would be dangerous, whilst the only hemorrhage that can take place is that of the fluid contained between the incision and the first or second valve.

Valves render veins essentially distinct from arteries, and it may be remarked, that the absence of them in these last vessels, is a further proof their tissue is not provided with vital contractility. In fact, if these, as the heart, contracted to propel the blood, this fluid would, in consequence, have as much tendency to return towards that organ as to proceed to the distant parts, and valves would be requisite at different distances in the arterial tubes, to check the first of these motions; but it is only in the origin of the aorta that they are found. Why is this? Because in arteries, the effect of the contractility of the tissue only is to be counteracted, which being performed without exertion, and by simple contraction, can return but a very small quantity of blood to the heart. One single obstacle, then, was required in the origin of the arterial system, to prevent a disturbance in circulation, which might be produced by the reflux, occasioned during the time of the systole from the contractility of the arterial tissue, a reflux that only takes place in peculiar cases; for generally, the contraction of arteries is the consequence of their containing less blood, which has been expelled during the time of the diastole. For this reflux to take place, it would be requisite that the effect of the contractility should during the systole, exceed the quantity of blood lost by the arteries during the opposite state.

Operation of the re-active Substances on the Veinous Tissue.

This tissue, in drying, becomes rather yellow, remains supple, and bends in all directions; so that these veinous cords are, in this respect, fit for uses to which arteries in the same state are not adapted.

This tissue putrefies quicker than that of the arteries, but less so than the others, and particularly the muscular. To ascertain this, I have submitted arterial trunks, and portions of intestines, or of thin muscular layers, to the action of damp air.

The veinous tissue is less capable of resisting maceration than the arterial, and more than that of many other parts; the water, in which it has undergone this process separately, is less fœtid than that in which an equal portion of muscular tissue has been macerated.

The shrinking of the veinous fibres is remarkably striking when immersed in boiling water, or in strongly concentrated acids. In these cases, they contract more than half their length, on which account, they become more conspicuous, and are also rendered fitter for investigation; I have frequently profited by this state; their contraction also thickens the parieties of the vein. If, when in this state, they are placed in boiling water, or in acid, they become softer, but much sooner in the latter than in the former case. They are sooner boiled than the arteries, and seem to admit of being reduced by a long continuation of this process to a pulpous state, a state of which arteries under similar circumstances are not susceptible.

Caustic alkali appears also to have rather a powerful action on veins. After having remained for a short time in this alkali, they become diaphanous, as it were, less bulky; do not completely dissolve, it is true, nor diffuse, as when immersed in acids, but visibly lose part of their elements, leaving a remarkable sediment, and the strength of the liquor is always reduced by the new combinations it has undergone.

SECTION II.

Parts common to the Organization of the System of the Dark Blood.

Blood Vessels.

The veins contain in their tissue, minute arteries and veins, which follow nearly the same directions as in the arteries,—they first ramify in the cellular membrane, give off small branches to the adjoining parts, then penetrate into the veinous fibres, winding in a variety of different directions, and finally terminate towards the common membrane, which upon injection, has appeared to me to receive more of them than that of the arteries.

Cellular Tissue.

The veins, like the arteries, are provided outwardly with two kinds of cellular tissue, the one, which is external, and of the same nature as that found in the interstices of all the organs, is loaded with fat, with a very thin fluid, and is only intended to unite the veins and the adjacent organs; the other, dense and firm, forms their immediate tunic.

In treating of the cellular system, this peculiar tissue has been noticed. No author has yet distinguished it from that which is generally extended, and from which, however, it differs essentially in the filaments of its texture, its dryness, in the constant absence of fat and serum, its remarkable resistance, &c.; when stretched, by tearing it from the veins with the fingers, it has the appearance of an intricate net work.

After having formed this outward covering to the veins, this cellular tissue, which is of a peculiar nature, analogous to the sub-arterial, submucous tissues, &c., plunges between the longitudinal veinous fibres, separates them, supplies them with a kind of sheath, and terminates in the common membrane, that seems to contain a quantity, and which, perhaps, is partly indebted to this circumstance, for the remarkable extensibility it possesses.

I have observed, that the existence of the cellular tissue in the parieties of the veins, is a distinctive and decisive character, that separates them from the arteries, with which, in other respects, they have not the slightest analogy.

Exhalants and Absorbents.

It appears, that no kind of exhalation takes place on the internal surface of the veins. This surface is constantly moist in the dead body, even though the vessels are empty; but as in the arteries, I attribute this phenomenon to a transudation that takes place after death. In fact, if a fluid had been exhaled, it would prevent the adherences between the veinous parieties, when during life the blood has ceased to pass through them, but every vein that has remained empty, closes, forming a kind of ligament, an effect, which, under similar circumstances, applies also to the arteries.

Absorption is also wanting in the internal surface of the veins. To ascertain this, I have attempted on the internal and external jugular veins, &c., the very same experiment before-mentioned, as performed on the carotid artery: I obtained a similar result, which has induced me to draw the same consequence. I have been led to try these experiments, in consequence of the opinion of several eminent anatomists, who have thought that the absorbents arise immediately from the veins and arteries. It is possible this may be the case in the ramifications, especially in the capillary system, as I shall state when treating of the absorbent system; but I do not believe any thing of the kind could ever be demonstrated in the trunks.

It appears then, that the exhaling and absorbing vessels of the veinous parieties, similar to those of the arteries, are entirely confined to the functions of nutrition, consequently that they are not very numerous. This remark is not only applicable to veins, but also to the whole vascular system of the dark blood.

Nerves.

1st. The veins differ essentially from the arteries in the paucity of nerves, proceeding from the ganglions that attend them: whilst these nerves provide the greatest part of the latter, with a kind of additional coating, they hardly extend over the former. This observation is easily made, by laying the venæ cavæ, the jugular, or azygos veins bare. 2dly. With regard to the side of the heart which receives the dark blood, it appears to possess as many nerves as that intended for the red, which proves, that these organs do not influence contraction, since such contraction is evidently weaker in the right side than in the left, whilst with the same proportion of nerves, an equal power should also exist. 3dly. The pulmonary artery displays but very few nerves. I am not yet perfectly acquainted with the connection existing on this side, between this vessel and the veins of the same description.

From this general view, it follows that the system of the red blood is evidently provided with more nerves than that of the black. In fact, things being nearly equal in the heart, and the difference being very striking between the branches of the aorta, and the veins that proceed to the right auricle, although the pulmonary artery, which I think rather probable, might be in some degrees better supplied than the corresponding veins, yet, the short distance these two species of vessels have to pass, would still leave an obvious disproportion.

ARTICLE III.

Properties of the Vascular System of the Dark Blood.

Veins in general, are loose and soft, and do not possess much elasticity, they partake of the character of a number of the other tissues of animal economy, and are, in this respect, essentially distinct from the arteries, which, as we have observed, are very elastic. Their vital powers, and the properties of their tissue, will now be particularly considered.

SECTION I.

Properties of the Tissue.—Extensibility.

VEINS, in regard to this property, are quite opposite to the arteries, which allow of tolerable extension in the longitudinal direction, but scarcely any transversely.

Veins are susceptible of but little extension in the first direction. When drawn in the amputated stump, or in the dead body, although actually extended, they are not elongated in proportion to the dilatations they undergo in varices. This may, perhaps, be less owing to the deficiency of extensibility in the tissue than to the curvatures being less numerous in these vessels than in the arteries, which are consequently longer. However, let the reason be what it may, the fact is not less certain.

Few organs, on the contrary, are so susceptible of being extended in a transverse direction as the veins. In the dead body, by injections of air, water, or fatty substances, &c. veins acquire an enormous size. In the living subject we perceive the varicous dilatations, such as those of large trunks, which produce obstacles to the course of the blood in the lungs, whilst arteries in general cannot be distended to twice their diameter, without both their common and proper membranes being torn. Veins may exceed even five times their diameter, without giving way.

We find, however, numerous instances of such accidents. Haller, in his important book, has quoted several. During pregnancy, then, ruptures have been noticed in the veins of the inferior extremities, and instances are not wanting where that had taken place in the veins of the head, where there has been violent pain of that part.

The vena cava, the jugular, and the subclavian veins have been suddenly ruptured, and produced death. We are well acquainted with the hemorrhage consequent to the rupture of the hemorrhoidal veins, &c. I believe that the excessive tenuity of the parieties of the cerebral veins, must frequently expose them to laceration in wounds on the head, when blows are inflicted on that part, &c. Undoubtedly, when the effusion is in the cavity of the tunica arachnoida, it can proceed from no other source than from the veinous trunks, which, clothed with a fold of this membrane, crosses this cavity to proceed to the cerebral sinuses. Now, we know that this is not unfrequently the case, and even that it often coincides with that in which the dura-mater, being loosened from the cranium, is separated from it by an effusion.

Are the extremities of the veins suddenly burst in apoplexy?

I have already mentioned, that, in this respect, we are still in the dark. All such cases of laceration are perfectly distinct from those in which the artery is affected with aneurism; they frequently occur; the dilatation being infinitely less than in numerous instances, in which they continue whole, most commonly they do not take place. The whole of the vein, including the cellular covering, gives way, &c. In true aneurisms, on the contrary, the artery is always ruptured, and whenever dilatation has reached a certain degree, it cannot fail. The two arterial coatings are easily lacerated; the cellular coat remains perfect. There is not, I believe, a single case of aneurismal tumour of a tolerable size, but is attended with laceration. Why is this? Because the extensibility of arteries can only take place to a certain degree. Laceration, then, proceeds from a deficiency of this property. On the contrary, it cannot be attributed to this cause in the veins. We are not yet well acquainted with their causes. In numerous cases the veinous tissue is certainly affected; this is undoubtedly the case in hemorrhoides, &c. Let us, then, be satisfied with having pointed out the distinctions between the arterial and veinous ruptures, until observation has thrown a light on all the causes of the latter.

If it be remembered that the arterial fibres are very numerous, and always circular; that those of the veins, on the contrary, are longitudinal and sparingly distributed over their vessels, it will be conceived why the first are less easily distended in the direction of their diameter, than in that of their axis, and why an opposite phenomenon, although less obvious, is observed in the latter.

Contractility.

This corresponds to extensibility. It is much more obscure in the longitudinal than in the transverse direction.

1st. It produces the contraction of the parieties of the umbilical vein, and of any trunk whatever, when a ligature has been applied, &c.

2nd. It is this which, when a trunk is punctured, causes the sudden flow of blood contained between two ligatures.

3rd. It appears to have a marked influence upon the blood drawn by bleeding.

4th. The numerous varieties in the calibre of the veins of the dead body, according to the quantity of blood they contain, evidently proceed from the extensibility and contractility of the texture.

5th. In the living subject the superficial veins are found in a variety of different states; dilated in summer, contracted in winter; considerably expanded by the warm bath, as may be seen with the venæ saphenæ in particular, from the pediluvium; contracted from the cold bath, projecting from a continued perpendicular position; diminished in the opposite state, they present to the inquisitive eye, at different times, a variety of appearances.

I very much doubt if those who have made so many calculations respecting the capacity of vessels, the rapidity of circulation, &c. would have been tempted to enter upon their task, had they attended numerous dissections or experiments performed on living animals: but all these varieties relate to the extensibility and contractility of the tissue.

SECTION II.

Vital Properties.

Properties of Animal Life.

Are veins capable of feeling?

The following is the result of experiments on this head:—

1st. If irritated externally by any mechanical agent whatever, no pain is produced, as Haller has observed.

2nd. The application of the ligature is not attended with pain, neither on living animals, nor in different surgical operations: in great amputations, for instance, in which it has been advised to tie the vein in the same manner as the artery.

3rd. If excited within, they afford the same phenomenon.

I have very frequently introduced an instrument to some considerable extent in one of these vessels, without producing any noise from the animal. I have always observed that this is a good method of ascertaining the sensibility of the heart, without opening the chest; a circumstance which, by the general disturbance it would create in the economy, might increase, lessen, or change this property to any extent. I then introduce a long instrument in the right external jugular vein, which has been punctured as for bleeding. This instrument reaches the heart in straightening the curves of the veins. In most instances the animal gives no signs of pain; but sometimes it happens otherwise, and the motion of the pulse is always accelerated. In man the end of a probe might be easily passed into the right side of the heart, through the external jugular vein: why, then, in particular cases of asphyxia, in syncopies that have resisted other stimulants, is this method of re-animating its action, not made use of? When fluids, unconnected with the economy, are injected in veins, let them be ever so irritating, the animal gives no sign of pain. Urine, bile, wine, narcotics, &c., may, in this respect, be thrown in with impunity. 5thly. On the contrary, when a bubble of air is forced into them, the animal by his cries expresses the most excruciating pains, is agitated, and struggles previous to death; but is this caused by the contact of the fluid on the common membrane? I do not believe it, because in general, a moment elapses between the cries of the animal and the act of injecting. It might certainly happen that pain would be experienced at that moment only, when the air, after crossing the lungs, comes in contact with the brain, a communication which, as I have before stated, always exists.

Animal contractility is evidently wanting in veins. The same experiments that have demonstrated its absence in the arteries, equally prove it here. I have tried them on the two species of vessels at the same time, and shall refer them for this point to the preceding system.

Properties of Organic Life.

Sensible Contractility.

This property does not appear to belong to the veins. Haller, by irritating them in various ways, has perceived in them no sensible motion.

I have occasionally made the same observation, either by irritating them externally or internally. In two or three instances, however, an evident contraction appeared to me to take place. On the other hand, as the veinous fibres have only a longitudinal direction, and they are but sparingly distributed, it is evident then, that admitting them to be muscular, the effect caused by irritating substances when applied, although real, cannot be ascertained without the utmost difficulty. The question then is not fully resolved, although I am much more inclined to believe that veins are not possessed of irritability. As the venæ cavæ at their origin are provided with fibres evidently fleshy, it is also evident that in this part they are possessed of the contractility we are now examining.

A further proof of the non-existence of sensible organic contractility in veins, or at least of its obscurity, is that, it is never found increased in diseases. Every organ possessed of this property is remarkable for its frequent excitement, which in the heart produces the strong and rapid pulse, in the stomach vomiting, in the intestines particular diarrhœas, in the bladder incontinence of urine, especially in infants, &c. But the veins never display a disturbance which, corresponding to these, might induce us to admit of the existence of a power of which it would be the climax, if I may be allowed the expression.

It may be remarked, that this observation is applicable to the arteries. That local agitation, that insulated disorder which particular parts of the intestinal tube sometimes present, are never seen in the arterial system? The irregularity of the motion of the blood is always general, because it proceeds from a single cause, namely, from the irregular impulse of the heart.

This method of ascertaining in a part the presence or non-existence of such and such vital powers, by means of affections which increase their action, claims, on considering these properties, an attentive consideration. Authors have not used this means of discovering them, and of deciding consequently on their presence or absence in respect to these organs.

Of the Veinous Pulse.

The motion veins undergo in peculiar circumstances, must not be mistaken for an effect of their irritability. It is occasioned by the reflux of the blood, which, unable to pass through the lungs, stagnates in the pulmonary arteries and in the right cavity of the heart, so that when this contraction meets with obstacles to its natural course, it returns in the way it came, in the same manner as when food cannot pass through the intestines, it is returned by the way in which it entered. This reflux, notwithstanding the valves, is continued to some extent; it is frequently very striking in the jugular vein, whenever the animal submitted to an experiment breathes, but with pain; it does not continue; it occurs three or four times, then ceases, and is repeated irregularly. We are aware it is also observed in the last movements of life when the lungs begin to be obstructed.

The vein is then evidently dilated; and then it contracts; but if the finger be applied, a sensation similar to that of the pulse is never felt, an undulation in the contrary direction is perceived. The reason is very clear. In the first place, there is no locomotion; in the second, the veinous parieties being loose, they could not strike the finger with sufficient force, admitting even the existence of this motion. It is, in fact, less the blood than the artery itself, that by the firmness of its tissue, occasions the sensation of the pulse. If it could straighten when empty, as it does when full, this sensation would be experienced nearly in the same degree, a remark that may be added to what has been stated respecting the pulse in the preceding chapter.

The contraction of veins in the motion of the reflux we are now considering, is no more than the contractility of the tissue called into action when the heart has ceased to convey the blood into its cavity; it then returns upon itself after having been pressed forward. It is nearly the same thing as when, in the dead body, a syringe being adapted to a vein, and this completely filled, if the piston be a little withdrawn, the fluid instantly returning, the vein contracts; or, as when the blood is discharged by a puncture, the vein does not contract; yet this does not imply any irritability.

I believe, that in some instances this reflux may proceed from an irregular motion of the heart contracting in a direction contrary to its natural one, although no obstacle exists in the lungs. What induces me to believe this is, that very frequently during experiments, at the moment the animal begins to suffer severely, the reflux takes place before the lungs could have been affected. The quickness with which pain affects the motions of the heart, rendering them more frequent, irregular, &c. is in general very remarkable. By giving the animal pain, the respiration may always be regulated at will; but the acceleration of the pulse constantly precedes that of respiration, which it seems to determine. I am convinced, that if the diseases of the heart were as frequent in the right side as in the left, they would very often produce this reflux and pulsation in the veins.

The limits of the reflux of the veinous blood vary. Haller has observed this reflux as far as in the iliac veins. In general, on account of the valves, it does not go beyond the large trunks.

I have demonstrated in my researches on death, that the colour of those who have died from strangulation, submersion, &c. does not proceed from this cause, because it evidently could not extend as far as the general capillary system; but this receives the dark blood from the arteries, which in such cases convey this kind of fluid.

The reflux of the dark blood in the veins, produced in the preceding cases, either by an obstruction in the lungs, or by the sudden disturbance in the action of the heart, take place also in the natural state, although in a much less degree. In fact, when the right auricle contracts, the whole of the blood does not enter the corresponding ventricle; the mouths of the veins being free, a part reflows into them. It is difficult to determine the limits of this natural reflux, which all authors have noticed. When the chest has been laid open it is easily observed; its extent might even then be ascertained; but in this instance respiration being no longer performed, as in the natural state, it is evident, that from this circumstance we are unable to judge of what takes place in the natural state.

Insensible Contractility.

This property, as well as organic sensibility, which, no more than the preceding, is ever separated from it, exists as well in the veins as in the other parts; it only presides over their nutrition, and appears more striking than in the arteries; at least those affections which particularly increase this power are more frequently observed in veins. The tissue of these vessels frequently inflames: 1st. Bell has produced several instances proceeding from external injuries; 2dly. We are perfectly acquainted with that attending the piles; 3dly. The cicatrization of the vein subsequent to bleeding is an effect of inflammation. This cicatrization is undoubtedly promoted by that deficiency of impulse to which the arteries are liable, but certainly in similar instances these would not so readily cicatrize. When a ligature has been applied to an artery, it requires, in order to perform a complete cure, and that it may separate without danger, that the parieties of the tube, inflamed by the action of the ligature, and more frequently lacerated by the compression, be placed in contact: from the difficulty with which arteries inflame, nothing is more difficult to produce than this adhesion. Hence the frequent hemorrhages subsequent to aneurism, and even to every important operation. The blood continues to flow for the space of thirty, and even forty days, or more, and the surgeon, on account of the difficulty with which the arterial tissue inflames, should always be very cautious in applying ligatures on large trunks. It frequently happens also that the obliteration of the artery is not owing to inflammation. Whilst the ligature stops the current of blood, that portion of the artery which is included between this and the first collateral branch, is gradually obliterated by the contraction of the tissue, forming a kind of ligament that stops the hemorrhage, when the ligature has separated from the vessel. I very much doubt if these cases are not more frequent than those produced by inflammation. Now the veins soon adhere after the ligature is applied, and when wounded they cicatrize almost immediately. In considerable wounds the ligature is, in the first place, as I have already stated, nearly always unnecessary, on account of the valves, and even afterwards, because the divided ends contract. Whenever hemorrhage proceeds from a vein it takes place immediately, and not after such a considerable interval as is observed in respect to arteries.

Every thing then concurs to prove, that in respect to the tonic powers, vital activity is much more considerable in the veinous than in the arterial system. The absence of cellular tissue, and its existence in the latter, are sufficient to account for this phenomenon.

Remarks on the Motion of the Dark Blood in the Veins.

From what we have just stated, and will be afterwards included in treating of the capillary system, it follows that when the blood has entered the vein, it is evidently no longer influenced by the heart. It is then certain that pulsation cannot exist in these vessels. In fact, 1st. This phenomenon proceeds from the sudden impulse consequent upon the contraction of the left ventricle; the blood being poured from every part into the veins through the capillary system, this impulse is necessarily wanting, and the exciting cause of pulsation does not therefore affect the veins. 2dly. Veins also do not possess either elasticity or resistance, indispensable faculties for its production in the tissue of the vessel in which that motion exists. They are not then susceptible either of the beating which causes the reflux of blood when the lungs are affected, the irregular motions of the heart, nor of the peculiar motion and undulation which take place when the arterial blood is made to circulate through their tubes; but in either of these cases the heart is constantly the principle of motion, which, without this organ, could not exist. This is the manner in which motion takes place in the veins. The capillary system, by the gradual contraction it undergoes, constantly supplies that of the veins with a certain quantity of blood. This new fluid, added to that already existing, causes a general motion. Now, as the whole veinous system is constantly full, it naturally follows that, whilst the fluid enters on one part, it should flow from another, or the parieties of the veins would be dilated; but as they are capable of resistance, and are, even to a certain degree, capable of acting over the blood, this fluid, unable to cause a dilatation in the veins, flows towards the heart.

The impulse, however, produced by the imperceptible contraction of the capillary system is not sufficiently powerful to be suddenly extended from one extremity of a vein to the other, particularly in those parts where the blood ascends against its own weight. In proportion as the blood enters these vessels, the weight of that which had preceded not being overcome, a general distention would ensue, and the fluid could not be returned to the heart; but this effect is counteracted by the valves which at intervals sustain the column of blood. Weakness of the veinous parieties, and the existence of valves, are inseparable. If veins were as strong as arteries, not being calculated for much dilatation, when the blood enters them they would, although deprived of valves, necessarily transmit the surplus to the heart; but on the other hand, this, in regard to circulation, would be attended with inconveniences that would continually impede the motion.

It appears it is not the insensible contraction of the capillary system alone, that forces the blood into the veins, but also that the roots of these vessels are possessed of a kind of absorbing faculty, by means of which they draw the fluid into this system. Now the insensible motion proceeding from this power of attraction, is evidently performed from the roots towards the trunks, as is the case with the lymphatic vessels: hence, since on one part the blood has a tendency to be propelled into the veins, and on the other, it is in some measure attracted by these vessels, it is evident that the original cause of the motion is the capillary system.

This impulse, communicated to the blood, is little more than the resistance this fluid meets with in its motion: thus, the slightest cause, the least resistance, checks this circulation. From hence, as we have seen, the necessity of anastomosis, and from hence, also, the necessity of auxiliary means to promote this motion; such as, 1st. The muscular action, the influence of which cannot be called in question, on seeing the stream of blood, in bleeding, accelerated by the motions of the muscles in the fore arm, or by the palpitation of the heart, when the blood rushes towards this organ after violent exertion, and on observing that varices are as rare in veins situate between the muscles, as they are frequent in the sub-cutaneous veins, &c. 2dly. The pulsation of the arteries, which in many parts are joined to the veins, and communicate to these vessels a kind of motion. 3dly. The motion of different parts, as that of the brain, whose mass, incessantly elevated and depressed, accelerates the circulation of the blood of the sinuses in an evident manner, as well as the continual locomotion of the gastric viscera, in respect to the veins contained in the abdomen, that of the pectoral organs in regard to those of the chest, &c. It is so very certain, that the circulation in the veins is aided by external motions, that if a limb has been confined for some space of time by the dressings for fracture, the vessels are frequently found in a dilated state. 4thly. External frictions, if not sufficiently extended to obstruct the veinous circulation, evidently promote it; this is partly the advantage derived from dry frictions. 5thly. A compression that is not irregular or too powerful, also promotes the veinous circulation, when the external organs are weak. Since the time of Thedan and Desault, we have become familiar with the advantages derived from tight bandages in cases of varicous ulcers, of varices, &c.

Since the principle of motion in the veinous circulation is extended throughout the whole general capillary system, instead of being confined to one single organ (as is the case with arteries), it is evident that this motion cannot be uniform; that it must vary according to the state of the capillary system in the different parts. This, in fact, we find to be the case, particularly in the external parts, where the veins are more or less swelled in proportion as the blood flows through their tubes with more or less rapidity. In arteries, on the contrary, the motion is every where the same; there is a sudden and general shock—an impulse, which, felt every where at the same moment, must necessarily be uniform throughout: thus we never find that some arteries are more filled than others, as is the case with veins.

In general, there is room for extensive research respecting the motion of blood in veins. Notwithstanding what authors have written on this question, it is still almost involved in darkness. These difficulties arise from our not being precisely acquainted with the mode and form of the motion communicated to the blood in the capillary system, what kind of influence the vascular parieties have upon this fluid, &c. Our discoveries in this respect are restricted to a few conceptions which I have just advanced, and which relate especially to the comparison of the veinous and arterial circulations. I believe that this comparison continued at some future day, will throw considerable light on the veinous circulation; in fact, as the first motion is better comprehended than the second, by thus opposing what we know respecting the one, and what we are labouring to discover of the other, we are proceeding, as it were, from the known to the uncertain.

In the following lines I shall give the summary of this comparison, which is still imperfect.

1st. General pulsation of the arteries; absence of this general motion in the veins.

2nd. Rapidity of circulation in the arteries; its slowness in the veins.

3rd. Greater capacity, and more tenuity in the parieties of the veins; the contrary state in the arteries.

4th. The necessity of other assistance to promote the veinous circulation; such means unnecessary for that of the arteries.

5th. The circulation in arteries performed by jerks; uniform in that of the veins.

6th. The blood in these last vessels liable to be influenced by the laws of gravity and other accessory causes; such influence ineffectual in the arterial motion.

Here is a series of phenomena which, from what has been already stated, evidently proceeds from the presence of an impulsive agent, and the non-existence of this in the veins.

1st. Constant uniformity of motion in all the arteries; variety of motion throughout the whole veinous system; dilatation and contraction, generally the same in the arteries of the dead body; remarkable variation in the veins of the different parts; other phenomena proceeding from the unity of impulse in the former case, and from the various sources of movement in the latter, &c.

In ascribing causes for the difference existing between the veinous and arterial circulations, several authors have strongly insisted, that the blood in arteries is propelled through tubes decreasing down to the capillary system, which is resistant, and that in veins, on the contrary, it flows through tubes gradually increasing up to the right auricle, which offers no resistance. The dark abdominal blood, however, is also circulated without an impulsive agent, through tubes gradually decreasing till they reach the capillary system of the liver, and its motion, however, is similar to that in the veins.

Sympathies of the Veins.

Sympathies in veins, like those in arteries, are very obscure. As the respective tissues of these two kinds of vessels are but seldom affected, and are not often the seat of inflammation and tumours, and therefore rarely affected with pain, we are but little acquainted with the influence they may possess over the other tissues. However, at that period when the various transfusions in the vessels were generally considered, acid and irritating substances, when introduced in the veins, have frequently been seen to produce sudden convulsions in different muscles.

In respect to the influence the other diseased organs may have over the veins, we are likewise much in the dark, as they are distributed in all parts in common with the arteries and nerves, it is frequently very difficult to ascertain if the vein itself, or in the organ it concurs to form, is the seat of the sympathy.

ARTICLE IV.

Developement of the Vascular System of the Dark Blood.

SECTION I.

State of this System in the Fœtus.

Veins in the fœtus have a disposition opposite to that of arteries; they are much less developed. It is not the large trunks of these vessels, as the vena cava, sub-clavian, iliac veins, &c. that should be compared, because the reflux of the blood at the moment of death causes these trunks to dilate, frequently even to such a degree as to deceive us materially in respect to their real size, and to induce us to believe they are considerably larger than, in fact, they are found to be in their natural state.

The branches and ramifications should be selected for comparisons. Now, it is easy to see that, in this case, the veins are nearly equal, but not larger than the arteries, which constantly happens in the adult.

The side of the heart, however, which receives the dark blood, and the pulmonary artery that forms a part in the system of the veins, are proportionally more capacious than these; because, not only they receive and transmit the blood of these vessels, but also that of the umbilical vein. To this last circumstance must also be attributed an anatomical fact, always applicable to the fœtus, and to it only, namely, that the very short trunk of the vena cava, which is extended from the liver to the heart, is proportionally much larger than that of the vena cava superior.

The slight developement of the veinous system, compared with that of the arteries, seems in respect to the fœtus, to proceed from the great consumption of matter in the process of nutrition, which at first being very rapid, less substance is consequently returned by the veins. This phenomenon, however, is not peculiar to the veinous circulation; we shall find that the excretory organs give out less fluid from the glands, and the exhalants are less active on their respective surfaces. A considerable quantity of blood enters the general capillary system of the fœtus; this is the reason why the arteries are so large. A great proportion of the substances remaining in the organs for their nutrition, and but little being supplied by the general capillary system, for the secretions and exhalations, very little is also returned by the veins.

The more the fœtus is advanced in age, the greater is the quantity of blood in the veins. At first, nearly the whole remains in the organs, for their formation. Towards birth, every thing approaches nearer to what takes place in the adult.

In this general phenomenon of the veinous system of the fœtus, a proportion is always maintained between the veins and the various parts according to the increase of the latter. Thus it is, that the greatest number of the superior parts, particularly the brain, being in this subject the seat of more active nutrition than the inferior parts, the veins in such situations are more considerable.

The fibres in the veinous parieties, although undoubtedly existing, can hardly be discerned at this age. I have only remarked that their small vessels are proportionally much less numerous than in arteries, whose trunks are overrun with them, as may readily be seen on the aorta.

The veins, although less dilated than subsequently, seem to be as fully organized; their parieties are very resistant, and even not so easily dilated, a quality that continues throughout youth. To this, I attribute the absence of varices at that age. In fact, as less blood is circulated through the veins, and they seem proportionally more resistant, it is evident they will be less disposed to yield.

SECTION II.

State of this System during Growth, and subsequently.

At birth, as we have seen, a remarkable revolution takes place in the system of the veinous circulation; the right auricle and ventricle receive the whole of the blood, a part of which, till then, was passed directly to the left auricle through the foramen ovale. This difference does not materially influence the capacity of the right auricle and ventricle; their forms, only, undergo some change, which I shall explain minutely, in the descriptive anatomy.

During the first years, the size of the veins is still inferior to that of the arteries. This inferiority is even continued during the whole time of growth: it may be ascertained by examining the external veins, they are as marked and perceptible in the infant as in the adult; compare the arm of a man with that of a child, admitting that there is a proportionate quantity of fat, and the difference will be striking.

The predominance of the cerebral veins over the others gradually subsides as age advances, because the brain has less necessity for nutrition.

At the age of puberty, and when the increase of stature begins to subside, the veins partake of that general plethora that seems to display itself, and from which, as we have seen, numerous diseases proceed.

When growth, in all directions, has ceased, the veins begin to increase in diameter; they become more prominent, and transmit apparently a greater quantity of blood. If an adult forcibly contract his muscles, we shall find all his veins considerably filled. A similar experiment in a youth, is not attended with a proportionate result; the application of ligatures presents the same difference.

SECTION III.

State of this System in Old Age.

In old age the veins become very prominent, when compared with those in youth; we might even be allowed to say, that in this respect, the two opposite stages of life are reversed. It is sufficient to consider the external habit in both ages, by examining the superficial veins, to be convinced of the accuracy of this assertion.

Let us be careful, however, not to imply by this greater developement, an addition of substance in the parieties of the veins, such, for instance, as the increase of a bone from a superabundance of calcareous phosphate. It is merely a dilatation of the parieties, that, instead of increasing, become even weaker and thinner. This dilatation is owing to the loss of their energy, and to the greater quantity of blood that is returned from the organs. In fact the process of decomposition evidently predominates over that of formation in aged subjects. More substance is removed from their organs than is added to them. The bones, I believe, are the only parts impregnated with a larger quantity of the substance intended for their nutrition; in every other organ the opposite state exists, from whence their contraction and decay. Now as it is to the veinous system that the residue of the decomposition of our organs is transmitted, it is not surprising that this should be dilated in old age, in the same manner as the arterial system conveying the materials for their composition should predominate in early life: the superabundance, however, of the dark blood in old age, is in some degree an illusion; in fact, it also depends upon the slowness with which circulation is performed in the veins in which the fluid imperfectly moved from a want of power in the capillary system, is disposed to stagnate, and even to dilate their parieties, as I have previously stated; thus it might happen that a less quantity of dark blood being returned from the organs, more might still be found in the veins than in those of the adult: this would proceed from the rapidity of the circulation being diminished. Then what takes place in respect to a single case of varix, that, for instance, in which the fluid accumulates because its progression is slower, would be extended throughout the whole system. It is not then requisite to believe that the superabundance of the dark blood in old age implies a real plethora, as that existing in the red blood of the infant, in which the arteries contain more fluid, and the blood is propelled with greater energy. From this we may perceive that the dilatation of the veins in old age is a further proof in support of the principles before stated, namely, that the capacity is constantly in a reverse proportion to the rapidity of the fluids that circulate through them. May I be allowed a simile, in some degree imperfect, but which may tend to elucidate what takes place in the veinous system: when the bed of a river is very wide above a bridge, it flows gently; but this being much confined under the arches, the rapidity of its course is considerably increased, that an equili-

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brium may be established. In the same manner in veins, there is little rapidity and much capacity in old age; much rapidity and diminished capacity in infancy.

Anatomists are perfectly acquainted with the difference between veins and arteries at the two opposed stages of life: they select aged subjects to study the veins; these subjects on the contrary, are perfectly unfit for arterial injections, so successful, and even, sometimes, too much so in the child, in which the whole appears one mass of vessels, whilst the investigation of the veins would be extremely difficult, or even impossible.

In old age the veins of the upper parts are generally more dilated than the others; this is owing to the constant weight of the column of blood; for, as it has been stated, the veinous circulation, from a deficiency of the power that produces it, is very liable to be influenced by mechanical causes: hence, varices are much more frequent in the lower than in the upper parts of the body, where they are rarely met with.

In women that have borne many children, this dilatation in the veins of the lower regions is still more striking, and in general it is more common in females. This affection appears also to be the badge of old age, whilst aneurisms, on the contrary, are less frequent at this period. Rupture of the veins has also been almost as constantly observed in old subjects as in the adult. I recollect no instance of it in infancy.

The pulmonary artery in old age is not dilated in proportion to the veins of the same system, because, being screened from external injury, and provided at its origin with an impulsive agent of a firm and resisting tissue, it is less disposed to yield than the others.

SECTION IV.

Accidental Developement of the Veins.

Veins admit of being accidentally developed in two different ways; 1st. In cancerous tumours, in fungouses, &c. in which cases a larger quantity of arterial fluid being admitted, they acquire a volume proportioned to that of the arteries; but as they are superficial, their increase is better seen than that of the arteries, which has led to the mistake that this increase is a distinctive character of cancers and other similar tumours; but it is only a consequence of the additional nutrition. The circulation of the blood takes place in these, with the same degree of rapidity as in the other veins; it is in no way obstructed; 2dly. There are cases on the contrary, in which the veins of a part dilate, because the blood cannot easily circulate in them. In ascites for instance, the whole veinous system of the abdominal parieties is increased; not because there is more blood to convey, for it is even less than in the natural state, but because the veinous coats, and the neighbouring parts, having in some degree lost their power, the circulation is much retarded; the slower the motion, the more the blood that circulates, and the more it will dilate the veinous parieties, forming a kind of general varix in one division of veins. A greater quantity of blood is not conveyed by the arteries in this than in the preceding instance. It is somewhat analogous to the varix of aged subjects.

ARTICLE V.

Remarks on the Pulmonary Artery and Veins.

Although in the statement I have given of the systems of the arterial and veinous blood, I have considered the pulmonary artery as forming a part in the veinous system, and the veins of the same description as continuous with the arteries, yet their nature is perfectly distinct. In reality it is only the two general membranes, forming the great canals, in which are contained the two kinds of blood, that are every where of a similar nature, from the general capillary system to that of the lungs. The tissues superadded to these two common membranes are essentially different. Thus the tissue of the pulmonary artery, although added to the membrane of the veinous circulation, is, with the exception of the difference in thickness, of the same nature as that of the aorta and its divisions. In the same manner, although united to the membrane of the arterial circulation, the tissue of the pulmonary veins is the very same as that of all other veins.

This uniformity in the tissue naturally implies uniformity in the functions: this, in fact, is really the case. The mechanical laws of the circulation of dark, are the same in the pulmonary artery as those of the red blood in the aorta. In the same manner the laws of the general veinous circulation preside over those of the pulmonary veins. Inspection proves this. Besides, it must unavoidably be the case, since the connection of the heart with these two kinds of vessels is the same as with the arteries and veins.

Each system of blood is then possessed of its two modes of circulation. Instantaneous motion, generally extended, and not a progressive supply of fluid; pulsation produced by actual locomotion; general straitening of every division of the same trunk at each impulsion of the heart; such are the general mechanical characters of the vessels for the red blood, as well as of that for the black. Non-existence of pulsation, slowness in the motion of the fluid, inability to straiten,

&c. are the general attributes of the veins in both circulations. There are, undoubtedly, general modifications depending upon situation. Thus, on account of the short extent of the pulmonary veins, their fluid is but very slightly influenced by gravity; they are never subject to varices; the motion of the fluid is rather more rapid in their tubes, since they have merely to propel it to the capillary system of the lungs, &c. Thus has the pulmonary artery, the branches of which are less curved, afforded me less striking pulsations than those of the aorta, &c.; but the general phenomena are always the same: these are only different modifications.

This explains why the general disposition is nearly the same in veins and in arteries, whether they are intended for the circulation of the red or that of the dark blood. Thus, for instance, the two arteries project each from a ventricle through a single opening, indispensable for the unity of the impulse communicated to the blood, to the uniformity of its course in the divisions of the large vessels, and to the simultaneous pulsation in every division. Veins, on the contrary, supply the heart with the two species of blood by several distinct openings, which is quite immaterial, since, as we have seen its motion in the veins is not uniform, but liable to be accelerated or retarded in any part, according to the impression received. Thus it may pass with rapidity into the superior, and slowly into the inferior vena cava, &c.

If from the preceding considerations the mechanism of circulation only be attended to, it is nearly indifferent either to consider with the ancients the great and small circulations; first, the course of the blood in the pulmonary artery and veins; then in the aorta, and the general veinous system; or the course of the blood, as I have done; first, in the pulmonary veins and aorta, then in the general veins and pulmonary artery. But if this important function be also considered, in respect to the phenomena of nutrition, secretion, and exhalation, the materials for which it supplies; to the general excitement it causes in all our parts, indispensable to maintain life; to the introduction of heterogeneous fluids in the body; or to the change of those fluids into our substance; then I believe it is indispensable to follow the plan I have pursued.

ARTICLE VI.

System of the Dark Blood in the Abdomen.

Situation, Forms, General Distribution, Anastomosis, &c.

There is in the abdomen a circulation of dark blood, quite independent of the preceding, disposed in the same manner, and admitting of this distinction only, that its course is not so extensive, and that it is not provided with an impulsive organ. This, generally described under the name of the system of the vena porta, is constantly met with in almost every species of the animal creation.

It arises from that division of the general capillary system belonging to the intestines, the stomach, the epiploon, the spleen, pancreas, &c., and, in general, to all the abdominal viscera concerned in digestion. Its origin is very peculiar. Every viscus in the abdomen, that does not interfere with the functions of digestion, is unconnected with the origin of this system. The kidneys and their appendages, as the atrabiliary capsules, the ureters, the bladder, the urethra, &c., the genital organs, the diaphragm, and even the parieties of the abdomen, &c., supply the preceding system with their dark blood, what is the reason that the organs of digestion are, in respect to the destination of their dark blood, excepted from the others in their whole extent? To answer this question would require that the purposes of the system we are viewing should be known, but they are still concealed from us.

Arising thus from the whole gastric appendage, this system is collected into two or three trunks, that soon unite into one, situate in the upper and right part of the abdomen, under the liver.

This common trunk soon divides again into several branches, which plunge into the liver by numerous ramifications, which are lost in the tissue of that organ.

It displays then the same general arrangement as the preceding, being composed of two trees, united in their opposed summits, which are intermixed. Suppose a fleshy impulsive organ in these summits, and it will be perfectly similar. The blood moves from one capillary system to another: first divided in very minute threads it unites into a mass which gradually increases till it reaches a fixed point, then divides again, and is lost in imperceptible streams like the former.

In the abdominal portion, the ramifications, branches, and trunks follow nearly the same order as in the general veinous system: the ramifications are situate in the organs, the largest in the interstices that separate them; the greatest part of the branches, placed between the lamellæ of the peritoneum, attend the arteries in these parts, and the trunks wind through the subjacent cellular tissue. In respect to the hepatic part, completely immerged in the liver, it is divided there nearly in the same manner.

In this system anastomosis display the following disposition: 1st. The hepatic portion apparently has none; all the branches and ramifications pursue separate courses. As the circulation in the liver is not liable to undergo alternate increase or decrease, &c., and the firm tissue of that organ protecting the vessels, the blood does not require the means of deviating from one part to another. Thus the two great divisions of the pulmonary artery and veins, which immediately plunge into the lungs where they are wholly imbedded, have communication. Thus, again, the branches of all the arteries and veins, contained in the internal parts of a viscus, are in general not provided with anastomosis. In the small branches of the abdominal tree they are very frequent. Along the course of the small intestines, arches exactly similar to those of the mesenteric arteries are found; less numerous on the large intestines, they are still very apparent, as well as on the stomach; they are wanting in the branches, and in the trunks.

In the system of dark blood in the abdomen, anastomosis is rendered indispensable by the frequent obstructions to which this fluid is liable; for it must be observed, this circulation, in respect to the abdominal parts, follows the same laws that regulate the motion in the other veins, that the power consequently, which causes circulation, is liable to yield to the slightest obstacle.

Now, in the various motions of the small intestines, a fold, rather too strongly bent on the veins by the pressure of these organs filled with food, when laying on the back or on the sides, and the veins are situate on a resisting surface, this, and a number of similar causes, will obstruct circulation in a branch, and force the fluid to re-flow through the anastomosis to another. It may also be remarked, that an obstacle which cannot influence the arterial circulation, on account of the power that propels it, may materially affect that of the veins, which is but feebly conducted.

The blood of this system, like that of the preceding, is influenced by gravity. Hence we find, that the hemorrhoidal veins, being more exposed to this influence than the others, are more frequently affected with varices; dilatations even are seldom met with in the superior mesenteric, gastro-epiploïc, spleic, veins, &c.; whilst, in no part are they so frequently observed as in the hemorrhoidal vessels: thus we have very seldom found the preceding system dilated in the upper, but frequently so in the lower parts of the body.

The system of the dark abdominal blood has but little communication with the general system. If anastomosis exist, it is only in the last divisions; yet this is a question. I believe these two fluids should be considered as distinct from each other.

Organization, Properties, &c.

Many authors (Haller particularly), believing that the system we are now considering is not provided with an impulsive agent, have admitted that these tubes possess a solidity of structure superior to that of any other veins; but, on due investigation, I have convinced myself it is absolutely the same. The cellular coating of a peculiar nature that clothes it, and which is analogous to that of the other vessels, is only somewhat more characterized; which, at first glance, gives these veins rather a thicker appearance; but, on removing this cover, the internal membrane is found of the same nature, but less capable of being extended. The longitudinal veinous fibres are not so easily discerned as in the preceding system. I even doubt if they exist in the trunks, where they might be better observed.

Both the hepatic and abdominal portions of this system, appear absolutely uniform in their structure, only the first is every where attended with a kind of membrane, that seems cellular, but whose nature has not, till this day, been properly investigated, and known by the name of the capsule of glisson. This capsule, intimately united to the substance of the liver, is less attached to the veins; so that when these are empty, they are frequently separated from it to some distance, which causes them to collapse when the liver is cut in slices. The object of this anatomical disposition is, I believe, still unknown.

The similarity of structure between the abdominal and general veinous systems, implies also, a similarity in the properties, sympathies, the affections, &c. I have frequently irritated in various ways, the mesenteric veins, (to which easy admittance is obtained), by drawing a part of the intestinal bundle, through a slight incision in the abdomen: the results have always been the same as in the preceding system, with this distinction only, that when air is introduced, the animal does not struggle, apparently suffers no pain, and the experiment is not attended with dangerous consequences, which proves still more, that it is not its contact with the veins of the heart that proves fatal, but its action upon the brain.

The common membrane of the system we are now considering, is distinguished from that of the preceding, by being completely deprived of valves. This seems to proceed from two causes, 1st. The course of the blood being shorter, the fluid can better dispense with this support. 2dly. The middle portion of this system being unprovided with an impulsive agent, there is no reflux, as in the preceding. In fact, at each contraction, the right auricle, as I have stated, returns a part of its fluid in the veins, which by means of the valves form an obstacle to it; here, on the contrary, the course of the fluid is constantly uniform from one capillary system to another,—there is nothing to cause a retrograde motion.

Remarks on the Motion of the Dark Abdominal Blood.

This uniformity in the course of the motion of the dark abdominal blood, is not only the result of the absence of an impulsive organ, but is also promoted, by the liver not opposing to this fluid such frequent obstacles as the preceding dark blood receives from the lungs. It may be remarked, in fact, that the liver is exactly to this system, what the lungs are in respect to the preceding: it is the boundary and termination of the circulation we are now examining.

Now, the liver not being influenced by any kind of dilatation or contraction, deprived of the fluid that incessantly acts on the lungs, the air, which loaded with various heterogeneous substances, is frequently apt to alter the vital powers of that organ, even to such a degree as to obstruct circulation, &c., its tissue formed of a resisting and granulated substance, in which no extraordinary motion can take place, excepting that of the general locomotion of the organ, has evidently none of those conditions calculated to produce frequent derangement in the course of the dark circulation, that exists within. Add to this, as I have before stated, the absence of the impulsive agent, and we shall conceive: 1st. Why, when the abdomen is laid open, neither the pulsation nor reflux in the veins of the abdominal system, which are observed in the preceding, are ever seen: 2dly. Why nearly the same quantity of blood is constantly found: 3dly. Why, consequently, we never observe, either in the common trunk that corresponds to the heart, or in the branches, any of those numerous varieties of dilatation and contraction, which are so frequently observed in the right side of the heart, and in all the large veinous trunks, so that in this respect, scarcely two subjects are found alike, whilst here it is always pretty nearly the same: 4thly. Why the liver is not subject to that immense variation of volume, which the lungs undergo. This even merits a particular consideration. However few bodies we may have opened, we must have observed that this last viscus is hardly ever found twice to contain the same quantity of blood; its weight varies considerably in this respect. Now all this proceeds from the greater or less obstacles the fluid has experienced in crossing the lungs at the moment of death. We may render it lighter or heavier in an animal, on destroying it by strangulation or hemorrhage, consequently by filling, or depriving of blood the extremities of the pulmonary artery. On the contrary, whatever may be the cause of death, the hepatic extremities of the abdominal system always contain nearly the same quantity of blood; besides, admitting that at the instant of death, this system contained more than usual, the fluid would be generally distributed, because there is no impulsive agent, which at that time, as in the lungs, might propel the greatest part to the liver. From this, it may be conceived why this organ has a firm and resisting texture, not admitting like the latter of being extended; a greater quantity of blood may sometimes penetrate it, it may even weigh more or less, according to the nature of the death. But these varieties appertain solely to the hepatic veins that open into the inferior cava, almost immediately under the heart; they depend upon the greater or less reflux that has taken place in that part, as well as in all the large veinous trunks, and are consequently connected with the state of the lungs; so that it may be affirmed, whenever this organ is so gorged with blood that the right auricle is distended, the liver also contains more of this fluid; but this phenomenon, which I shall examine when speaking of the liver, does not relate to the system we are considering.

The mechanism of this circulation is precisely the same as that of the veins in respect to their abdominal portion. With regard to the hepatic portion, it is the only one of the kind in the economy; it bears no analogy with that of the arteries, since in these the heart is nearly all, and in the other there is nothing corresponding to that organ; for, as I have frequently ascertained, there is certainly no kind of contraction whatever in the common trunk of the two trees. It is then the same motion that is continued from the gastric viscera to the liver; besides, with respect to this motion as well as the former, many difficulties must be removed. On reading what has been written respecting the motion of the general veinous blood, no judicious mind feels satisfied.

It cannot be denied that external agents interfere a good deal with this circulation as well as with the other. The habitual elevation and depression of the diaphragm, the corresponding motion of the abdominal parieties, the alternate dilatation and contraction of the hollow viscera of the abdomen, the continual locomotion of the small intestines, &c.; all these causes undoubtedly influence the motion of the dark blood of the abdomen. I even believe that the deficiency of a great part of these contribute as much as the perpendicular position, in lessening the motion in the hemorrhoidal veins, and in producing varices in these parts.

This influence, however, is not such as Boerhaave had thought, that circulation could not be performed without it. In fact, the abdomen of an animal being laid open, the blood is equally transmitted to the liver, and flows in the same manner from an open vessel; but after a short time a striking feebleness is seen even before the general circulation begins to be languid.

Remarks on the Liver.

The use of the liver, by being the boundary of the dark abdominal blood, as the lungs are for the veinous circulation of all the remainder of the body, gives this viscus a degree of importance which is foreign to all the other secretory organs. Several authors perceiving that the volume of this organ is enormous, when compared with the fluid it emits, have suspected that it is intended for other uses besides that of separating the bile. This suspicion seems to me a certainty. In fact, if we compare the excretory canals and the hepatic reservoirs to the same organs in the kidnies, the salivary glands, and even in the pancreas, we shall find they do not exceed them, that they are even inferior to those of the former; then compare the mass of the liver with that of the loins, of the salivary glands, &c. and we shall perceive the difference. If on the other hand we examine the bile that is expelled with the fæces, if the intestines be opened at the different periods of digestion, as I have done to ascertain the quantity of this fluid they contain; if we starve an animal in order that it may accumulate separately in the intestines; if the ductus choledochus be tied to retain the bile, &c. it will be impossible not to be convinced that the quantity of this fluid is inferior to that of urine, and particularly how disproportionate it is with the volume of the organ. The bulk of this viscus only, equals at least that of all the other glands united together; if on the one side we place the bile, on the other all the secreted fluids, the urine, saliva, the pancreatic juices, the semen, the mucous juices, &c. we shall find an enormous difference.

Since then, the secretion of bile is not the only function the liver is intended to perform, it must fill some other use in the economy, of which we are completely ignorant. It cannot be doubted that this organ must be connected with the system of the dark blood, and being the boundary of that motion, that it is even especially related to this system. The following considerations seem to prove that its function is of the utmost importance.

1st. The liver exists in every class of animals; even in those in which the greatest part of the essential viscera are very imperfect, this organ is very striking; 2dly. The greatest number of our passions particularly affect the liver, some even possess over it an exclusive influence, whilst the greatest number of the other glands are not affected by them. In diseases the liver takes as active a part as the most essential viscera in the economy. In a considerable number of nervous diseases, in hypochondria, melancholy, &c. its influence is immense, when compared with that of the other glands. The facility with which its functions are disturbed is sufficiently known; it has undoubtedly nothing to do with many diseases called bilious affections, that are seated exclusively in the stomach, but it certainly acts an important part in a number of these affections. Since it cannot be doubted that jaundice proceeds from some serious affection of this organ, we must conclude, that the cause of those affections which tinge the face of a yellowish colour is in this viscus, which had not sufficient power to produce jaundice. Whether or not the circulation of bile with the blood occasions this colour, is of very little importance; it is certain that it is produced by the state of the liver. Now the multiplicity of these cases proves how very frequently this organ is affected; more frequently, without doubt, than any gland in the economy; 4thly. Shall I speak of the organic affections? If we compare, in dissection, those of the liver with those of all the organs in the same class, we shall find none to equal it in this respect. The kidnies approach it in the frequent diseases of their tissue, but are far from supporting the comparison. 5thly. Are we not well convinced of the influence of the liver upon the temperaments? Who is not aware that its predominance impresses on our external habit, on the functions or passions, and even on the temper, a peculiar character, remarked by the ancients, and confirmed by modern observations? The other glands, in respect to their influence in the economy, offer nothing similar; 6thly. The liver in common with the heart and the brain, is the first viscus that is produced, it precedes every other organ in its developement, and in this respect is incomparably superior to all the glands.

From all these considerations, and from many others that might be added, we may, I believe, conclude, that the unknown part which the liver acts in the animal economy, besides the secretion of bile, is of the utmost importance, and highly worthy of fixing the attention of physiologists.

It has lately been set forth, that the liver acted as an auxiliary to the lungs, to divest the blood of its hydrogen and carbon. I do not conceive how this fact can have been verified by experiment; but I may affirm that the liver certainly does not convert the dark blood of the abdominal system into red. 1st. The blood of the right auricle has the same colour as that of the vena cava inferior; but if the blood had been red on flowing from the hepatic veins, it would certainly have imparted a lighter hue to the former. 2dly. Having opened the chest and the abdomen of a dog, by means of a curved needle I have tied the vena cava on its entering the heart, and also above the loins; then, loosening the liver behind, I have divided the portion between the two ligatures, in which the hepatic veins open; the blood emitted was as dark as that from any other part of the system. 3dly. If we remove the liver of a living animal, and instantly examine the veins, we shall find they contain a specie of blood similar to that of the other veins. 4thly. When the liver is cut in slices in a living animal, an analogous fluid will flow from the back part of this organ, excepting a few minute red streams furnished by the last ramifications of the hepatic artery; the result is quite different when the same experiment is applied to the lungs.

If the veinous blood of the abdomen undergoes some modifications in its nature in the liver, these certainly do not influence either the hue, the consistence, or the touch.

The general opinion is, that the dark blood of the abdomen serves for the secretion of bile, and the hepatic artery is only intended for the nutrition of the liver: this opinion has been adopted by Haller: I have myself introduced it in my lectures; but I am far from considering it so strictly demonstrated as is generally admitted; the following observation will prove that it should only be received as a supposition, even an uncertain one.

1st. It is said, that the blood of the liver, blacker, more unctuous, impregnated with emanations proceeding from the fæces, even of a bitter savour, approaches more the nature of bile than the arterial blood; that it is consequently better fitted to secrete this fluid. I am ignorant if this blood has been comparatively analysed; but I have certainly not found any distinction in its external properties: in one experiment I thought that I had perceived a few unctuous drops floating with the fluid; but I was deceived: several subsequent experiments have rectified the error. I very much doubt if it can ever be demonstrated that the alkaline particles of the food and of the fæces enter into the vena porta: this is an idle opinion. 2dly. It is said that the volume of the liver is considerable in proportion to the hepatic artery: this is correct; but it is not with the volume of this organ that this artery should be compared, to ascertain if it furnish the elements for secretions, since we have seen it is impossible that the whole of its substance should be intended to separate bile; the comparison should be established with the biliary canals and their reservoir: now this artery is perfectly proportionate to these canals; there is between them nearly the same connection as between the renal artery and the ureter; the biliary tubes, on the contrary, are very evidently out of proportion with the vena porta. 3dly. It is said, that the slowness of motion in this vein accommodates the secretion of bile; but on what positive notion is such an assertion grounded? Why should not slowness of motion be dispensed with in respect to this secretion as to any other? 4thly. It is said, that after tying the hepatic vein, the secretion of bile was continued; but when the connections between the parts are known, the slightest reflection will be sufficient to conceive, that a ligature cannot be applied without being attended with that destruction of parts in which nothing further can be distinguished. I have attempted it once, but could not continue; indeed I was almost convinced of this before. 5thly. It is also stated that the dark blood is better calculated to furnish the elements for bile than the red; but in what? Is it because this fluid has more hydrogen and carbon? Then again, the dark blood must also furnish the fat; but all anatomists coincide in saying this substance flows from the exhaling extremities of the arteries: the same observation applies to the marrow, serum, and, in general, to every unctuous fluid. A fine injection of the hepatic part of the veinous system of the abdomen proceeds to the biliary vessels; but on injecting the hepatic artery, a similar occurrence takes place. 7thly. The dark abdominal blood, it is said, receives, in the spleen, qualities essential to the production of bile; but the secretion of this fluid may evidently take place without the concurrence of the spleen. 8thly. It is said, that at the moment a ligature is applied to the vena porta, bile ceases to be secreted: the trunk of this vein is more readily tied under the duodenum than the hepatic artery; but how could it be ascertained what was going on within the liver? Has the opinion been drawn from the fluid in the hepatic duct? But if the duodenum be opened, we shall find in general that bile is not seen to run from the opening of the ductus choledochus, undoubtedly because the contact of the air has produced irritation, and caused this canal to contract. This phenomenon, then, observed subsequent to the application of the ligature, is not conclusive; besides, towards the time of digestion, too small a quantity of bile flows through the duct to enable us to appreciate it. Finally, what inductions can be drawn from an animal, the abdomen of which is laid open?

I believe these various reflections will prove that we have not, till this day, a sufficient number of direct proofs to decide to which of the two, the dark blood of the abdomen, or to the red, that the secretion of bile appertains. I ascribe this function no more to the one than to the other; I only say, it must be referred to further examination, and that this instance proves, that the opinions the most generally received in physiology, those consecrated by the sanction of all the eminent authors, frequently rest on very uncertain grounds. We are still far distant from those days when the science will be nothing but a succession of facts strictly deduced from each other.

The hepatic artery has been assimilated to the bronchial, and the vena porta to the pulmonary artery. This is correct, in reference to the general disposition; but in regard to the functions, where is the proof? On the contrary, I have previously established, that those of the two last vessels have not the same result. Before deciding, let us then wait for later and positive researches; till then, let us not attribute the secretion of bile either to the hepatic artery, to the vena porta, or to both in common. It is undoubtedly produced by one of these three, but which are the vessels that secrete the bile? what part the dark abdominal blood acts in the liver, if from this fluid the bile be not separated? what function, in short, does the hepatic artery perform, if it has nothing to do with this secretion? Here are several questions still to be resolved.

The opinions of physicians respecting the influence of the dark abdominal blood, in diseases, have also been suppositions; it may certainly be the case that the phrase, *vena portarum, porta malorum,* in point of signification may be very correct, but in the present state of the science it is nothing taken in a literal sense, but a play upon words. If it be used to express how frequent the affections of the liver are, it is no doubt correct; but if intended to express the influence which the vena porta bears in those diseases, it is vague and unsupported by positive facts. The more dissection is attended to, the more we shall, I believe, be convinced how indispensable it is to employ accurate and perspicuous language, divested of all those pretended ingenious ideas, that certainly do honour to their authors, but which retard the science, by introducing an hypothetical mode of conception, so contrary to the spirit of observation.

Remarks on the Course of the Bile.

Notwithstanding this question is in some degree unconnected with my subject, yet, as the dark blood of the abdomen may really influence the secretion of bile, (as my experiments, besides, on this head accurately determine the course of this fluid,) I do not think it useless to relate them here. Whatever more is to be known respecting the uses, the mechanism, &c. of this secretion, is related in the books on physiology, to which I refer.

It has been long disputed if there exist a cystic bile and hepatic bile; if their nature be different; if their quantity varies, or increases, &c.: various and even opposite opinions, as Haller has judiciously observed, have all been supported by numerous experiments performed upon living animals; these experiments, although contradictory at first glance, were not so, however, in reality, of which I have had frequent opportunities of being convinced, by repeating them at the different stages of digestion, and during the abstinence of the animal, which had not been done before with accuracy. The following is what I have observed in the dogs, made use of in my experiments.

1st. During abstinence, the stomach and the small intestines being empty, the bile in the hepatic and common canals is yellow and clear; the surface of the duodenum, and jejunum, is tinged by a bile of a similar appearance; the gall bladder is very much distended by a greenish bile, bitter, and of a deeper hue, in proportion as the fasting has been longer continued.

2nd. During digestion in the stomach,—that may be extended to some length of time by giving the dog large pieces of meat, which the animal swallows without chewing,—things remain nearly in the same state.

3rd. At the commencement of intestinal digestion, the bile in the hepatic canal still remains yellow; that in the ductus choledocus acquires a deeper hue; the gall bladder is not so full, and its bile appears of a lighter colour.

4th. Towards the end of digestion, and immediately after, the bile of the hepatic and common ducts, that contained in the gall bladder, and that extended over the duodenum, have precisely the colour of the common hepatic bile; that is to say, a light yellow, and not very bitter. The gall bladder is only half filled, and not contracted.

These observations, frequently repeated, evidently prove that the following is the manner in which, during abstinence and digestion, the flow of bile takes place.

1st. It appears that the liver always separates a certain quantity, which is however increased during digestion.

2nd. The bile furnished during abstinence is shared between the intestine, continually dyed with it, and the gall bladder, that retains it without pouring any part through the cystic canal; and, in this case, it acquires a deep hue, and an acrid character, without doubt necessary for the digestion that is to follow.

3rd. When the food, having been digested by the stomach, passes into the duodenum, the whole quantity of bile which, till then, was divided, flows into the intestine, and even in greater quantity. On the other hand, the gall bladder also pours that which it contained on the alimentary pulp, which is thus completely imbued with this fluid.

4th. After the intestinal digestion is completed, the hepatic bile lessens, and begins to flow partly into the duodenum, and partly to reflow into the gall bladder, where on being examined it is found clear and in small quantity, because it has not yet had time to darken and accumulate in abundance.

Then there is this difference between the two species of bile, that the hepatic portion flows almost in an uninterrupted manner into the intestine, and that of the cyst in the absence of digestion returns to the gall bladder, and reflows towards the duodenum, whilst this function is performing; or, rather, it is the very same fluid, one portion of which always retains the character it bore on flowing from the liver, the other acquires a distinct one in the gall bladder; the diversity of colour in the cystic bile, accordingly as it has remained stagnant more or less, has the utmost analogy with that of urine, which retained a longer or shorter space of time in the bladder, is found of a deeper or lighter colour.

As to the course of bile with regard to the stomach, I believe that this organ always contains a certain quantity of this fluid: when empty, it is found to contain a mixture of gastric and of mucous fluids, more or less abundant, sometimes mixed with small bubbles of hydrogen that take fire on bringing them near a lighted candle, and are most generally tinged of a striking yellowish hue, proceeding from the bile that has passed through the pylorus. Haller asserts, that this reflux does not constantly take place; Morgani affirms it is constant with man. I have not dissected a single dog in which this has not proved to be constantly the case, when the stomach was empty, and particularly, if that state had been continued for some time. Dead bodies are not very proper subjects for resolving this question, because the nature of the disease almost unavoidably affects the course, the nature, and the colour of the bile. I shall explain, in the next volume, what consequences are to be drawn from this observation, in respect to bilious vomitings.

In the state of fulness, it has appeared to me impossible to ascertain the reflux of the bile; at other times, I have seen between the alimentary pulp and the parieties of the stomach, yellowish gastric fluids, but this mass is never impregnated with this colour.

The bile that re-flows into the stomach has constantly, from its light colour, appeared to me the hepatic bile. I have opened, I believe, a sufficient number of living animals, to affirm that in the state of health, that very green fluid characterized, resembling, as it is said, the colour of leeks, which evidently proceeds from the gall bladder, and is vomited in peculiar diseases, is never found in the stomach. The reflux of this bile appears to proceed from this affection. This observation accords with that above stated, namely, that the hepatic bile alone flows into the duodenum during abstinence. This only, then, as in fact is ascertained can reflow into the stomach. During the time of intestinal digestion, when the cystic bile flows, it is evident that the food continually passing from the pylorus, prevents it from entering this tube to reach the stomach; the fluid found then in this organ, when full, was there before it had begun to be emptied by its peristaltic motion.

When the gall bladder is laid open in a corpse, the bile is found to display, according to the different kinds of diseases, a variety of colours, from black as deep as ink, down to a kind of transparency. Can we after this be astonished, if vomitings, the produce of which is cystic bile, forced contrary to its natural course into the stomach, afford matters of such various colours.

Developement.

The system of the dark abdominal blood is not insulated in the fœtus; by means of the communication of the veinous canal it forms but one with the two preceding. There is in reality then, but one single vascular system in the fœtus, whilst in the infant that has breathed, there are three perfectly distinct from each other, two for the dark, and one for the red blood. At this stage of life it is with the umbilical vein in particular that this system is continued: the liver is a common centre, where both arrive from opposite sides, and where they are confounded as it were in one common trunk. The two columns of blood they convey, do not directly meet their respective directions, forming a very remarkable angle.

When the opening of the arterial duct is attentively examined in the common trunk of these two veins, it is found naturally open to the umbilical fluid, and that the blood of the vena porta, on the contrary, cannot penetrate it: in fact, there is a small fold, in the form of a valve, though not so strongly marked as many others. This is nothing more than a kind of projection, situate between the end of the vena porta and the veinous canal, which reduces the opening of the latter to such a degree, as to become evidently narrower than the diameter of its canal. The blood flowing from the vena porta, and running along this fold, applies it against the opening, and forms an obstacle to itself; the fluid proceeding from the umbilical vein, on the contrary, falling perpendicularly upon this aperture, displaces the projection, and penetrates into the canal.

From hence it follows that the veinous canal is evidently intended to convey into the vena cava the residue of the blood of the umbilical vein: I say the residue: in fact, as this vein is very large, and the canal small in proportion to its diameter, it is evident that the greatest part of the blood penetrates the liver through the different ramifications that enter its substance.

The vascular system of the abdomen is proportionally less developed in the fœtus than at a later period, and consequently carries less blood to the liver: it is, in this respect, similar to the other veins; I have observed, however, that its deficiency in the liver is not proportionate with the surplus admitted in the adult, in respect to the umbilical vein. This organ then, in the fœtus, is constantly impregnated with a greater quantity of fluid than at any other age; this explains why, 1st. The nutrition of this organ is so complete, and its volume so considerable: 2dly. Why, again, in proportion to its size, it is heavier than in the ensuing ages: 3dly. Why, when it is cut in slices, a greater quantity of blood comparatively flows from it; why, as I have stated it before, when the liver of a fœtus cut in slices, has been dried, they are reduced to a small compass, although of the same thickness as those taken from the liver of an adult, or of an aged subject.

The disproportion of the volume of the liver in the fœtus is so much the more striking as it draws nearer to conception; it is the same as in respect to the brain, the nearer the fœtus approaches birth, the more this organ also acquires the proportions it will bear to the other organs in the adult. From Portal's observations, it is ascertained that this predominance of the liver is most remarkable until the seventh month of pregnancy; this circumstance seems to proceed from the umbilical vein conveying comparatively more blood to the fœtus as it is less advanced in age.

At that stage, the blood of the umbilical vein, and that of the vena porta, or a great part of them, are evidently united in the common trunk. Are these fluids of a similar nature? Experiments have proved nothing in this respect. But Baudalocque has told me, he had frequently observed that the fluid of the umbilical vein is redder; that this fluid even approaches the arterial blood. I have not strictly observed this fact in any other animal than in the young Guinea pig, in which the transparency of the cord does not exhibit any material difference between the blood of the arteries and that of the umbilical vein; but this distinction may be more striking in man. Now, in this case, the blood of the umbilical vein seems to acquire this reddish hue in the liver, for most undoubtedly it is uniform in the circulation of the fœtus beyond this organ, as I have frequently ascertained.

At the time of birth, the blood ceasing to flow through the umbilical vein, the liver is no more then than the boundary of the dark abdominal blood; a kind of revolution then takes place in this viscus. The different canals that conveyed to it the blood of the umbilical vein do not close, but exclusively transmit that of the vena porta, which vessel rather increases in capacity, because the commencement of digestion in the gastric organs attracts a greater quantity of arterial blood, and more, consequently, is returned by the veins. This trifling increase, however, is no compensation for the loss of blood from the umbilical vein. Thus, the volume of the liver decreases in a sensible manner.

In respect to the veinous canal, it closes by the contraction of its tissue. The blood flowing through the vena porta has no tendency, as I have before stated, to flow in this canal, because it is not in its direction; it passes in preference through the hepatic vessels, and then the circulation in the liver begins, as it is ever afterwards continued.

Such then, is the difference caused by birth in the hepatic circulation: 1st. Less blood, and but one kind of this fluid reaching the lungs: 2dly. Interruption of all kind of communication between the dark abdominal blood and the rest: 3dly. A proportionate reduction in the volume of the liver. Hence, a reverse phenomenon at the moment of birth, in respect to this organ and the lungs; this increases both in activity and size, the other decreases. The immense quantity of blood that previous to birth reaches the liver, and the size of this organ, when compared to the small quantity of bile that flows from it, are evident proofs that it was intended for other purposes than the secretion of this fluid. No kind of doubt can remain in this respect; it is a further proof that in the adult the disproportion of the organ with the fluid, although not so considerable, also implies that this viscus is intended for some other important function, with which we are unacquainted.

At birth there must exist a precise connection between the obliteration of the veinous canal, the foramen ovale, and that of the arterial canal, between the increased action of the lungs and the reduced action of the liver, &c. We judge of this connection without being acquainted with it, because, as I have previously stated, the circulation of the fœtus is still involved in obscurity. I only observe, that the predominance of the liver anterior to birth, does not imply a similar state in the system of the dark abdominal blood; it depends exclusively from the umbilical vein: thus the proportionate volume of this organ gradually decreases, particularly in the left side, where this vein was extended, as Portal has observed. It is a very delicate matter indeed, to fix the period when the equilibrium is generally established.

In youth, the system of dark abdominal blood, as well as the general one, is rather deficient in activity. It is towards the thirtieth or fortieth year that it seems most active; this is the period for gastric diseases, for piles, for melancholy,—a period that is so much connected with the state of the liver.

In old age, the dilatation of the dark abdominal blood is much less striking than the preceding; its vessels preserve nearly the same diameter as in the adult, which, from the principles already admitted, supposes less reduction in the rapidity of its circulation. It is never found ossified in any way whatever; a phenomenon that evidently assimilates its common membrane to that of veins, and distinguishes it particularly from that of the arteries.

CAPILLARY SYSTEMS.

The two great vascular systems of the red and the dark blood arise from, and terminate, as we have previously stated, in capillary vessels, that form in the lungs, as well as in all the other parts, their respective limits, and in which the fluids are mutually changed. Hence, there are evidently two capillary systems, perfectly distinct and opposed to each other; the one generally extended throughout the whole system, disseminated in every viscus, is that in which the red blood is transformed into black: the other exclusively restricted to the lungs, presents the reverse phenomenon; in its divisions the dark blood is converted into red.

The capillary vessels affording both an origin and a termination to the dark abdominal blood, are intermixed on both sides with those of the general capillary system, since in the abdomen they form a continuation to the arteries, and in the liver they give rise to the veins; I shall pass them over unnoticed in these present considerations, and regard only the general and pulmonary systems.

These two capillary systems, especially the former, still claim our more particular attention, because; 1st. The circulation is actuated in this system by laws quite different from those which in the other parts preside over that motion; 2dly. Because the greatest number of the important functions of organic life, such as secretions, nutrition, exhalations, &c. take place in it; 3dly. Because their minute canals are, in numerous cases, affected with diseases, and the focus of the various inflammations, metastasis, &c.; 4thly. That animal heat is especially produced in these capillary tubes, &c.

The lower classes in the animal creation positively possess nothing more than a capillary circulation; their fluids are never united in considerable masses in canals that convey them to all the parts, and subsequently return them from these parts. There is merely an imperceptible oscillation, as it were, of these fluids, in very numerous and minute tubes. This mode of circulation is one of the links, or rather transitions, between the animal and vegetable, which, deprived of a perceptible circulation, as the zoophytes, evidently possess nothing more than insensible and capillary circulation. I shall first consider the general capillary system, and afterwards that of the lungs.

ARTICLE I.

General Capillary System.

This system exists in every organ; all, in fact, are composed of a considerable number of capillary vessels that cross, unite, separate, and ultimately re-unite, by communicating with each other in numberless different directions. The larger vessels of those amongst the arteries through which the blood is circulated by the influence of the heart, and those amongst the veins, corresponding with the former, do not actually interfere with the structure of our organs; they wind in their interstices, and are imbedded in the cellular tissue that separates their lobes; but the capillary tubes alone are essentially a part of these organs, so intimately combined with them as in reality to form a part of their tissues. It is in this respect the animal body might, in truth, be considered as an assemblage of blood vessels.

From this first glance, it is evident that the extent of the general capillary system is immense, that it embraces the most minute divisions of our parts, that the smallest particle can hardly be conceived without including these vessels; from hence it follows, that this system is not merely intermediate to the arteries and the veins, but that organs of exhalation, secretion, &c. arise from it. It is this system also that gives rise to such vessels as are intended to convey the nutritive substance to all our organs; it should be regarded as existing in parts where the arteries penetrate, as well as in those to which they do not extend.

SECTION I.

General Division of the Capillary Vessels.

SINCE this system is not solely intended to unite the arteries with the veins, to convert the dark blood into red, it is evident that other fluids besides the blood must circulate through them; this, in fact, is proved by observation. There are numerous parts in the animal economy in which white fluids are exclusively circulated. The hypothetical opinions of Boerhaave respecting white arteries, decreasing vessels, &c. are sufficiently known; they are met with in every book. Here I shall only state what can be strictly demonstrated. That in the general capillary system there are parts in which the blood circulates, others where there are white or greyish fluids only, as may be ascertained by inspection, and requires no further proof. But what is the proportion of these fluids in the various organs?—such is the object of our researches. Now there are parts in the capillary system where the blood predominates almost exclusively; others, in which it is circulated in common with different fluids; others, in short, where these fluids only are met with.

Of the Organs in which the Capillary Vessels contain Blood only.

It appears, that in the muscular system, in the spleen, and in some parts of the mucous surfaces, as in the pituary membrane, the blood in the capillary tubes predominates to such a degree as nearly to exclude every other fluid. Very few other vessels are demonstrated by fine injections; the arteries and veins being very abundant in these parts, the blood, or at least its colouring substance, is there found, as I shall notice in two different states; on one part it stagnates, and thus serves to colour the organ; on the other, it circulates and contributes to its nutrition, excitement, &c.

Of the Organs in which the Capillary Vessels contain Blood and other Fluids.

These organs are most numerous in the animal economy. The bones, the cellular tissue, the serous membranes, part of the fibrous system, the skin, the vascular parieties, glands, &c. present this distribution in a very striking light.

To convey a correct idea of the capillary system in these kinds of organs, let us select one in which it may be easily examined, that of the serous membranes, for instance. When laid bare in a living animal, the small quantity of blood contained in their capillary tubes is easily ascertained through the transparency of that membrane; under this tissue numerous ramifications are met with, but they seem to be contiguous only with the system; for instance, if in a young Guinea pig we remove the peritoneal coat of the stomach, the red arteries that at first sight had appeared inherent to this coating, remain uninjured: the whitish or greyish appearance of these membranes is undoubtedly owing to the small quantity of blood their minute tubes, arising from the subsequent trunks, contain. If after having thus laid bare a serous membrane, to ascertain the quantity of blood it contains in the natural state, it be irritated by any means whatever, after a longer or shorter space of time it will be covered with innumerable reddish streaks, so multiplied even as to convert their whitish appearance into that peculiar to the mucous surfaces. If we inject a fine fluid into a dead body, it will so completely fill the capillary system of the serous surfaces, that of the peritoneum for instance, that these surfaces will appear completely black, and formed only of an intricate net-work, whilst in the living subject very few of these vessels can be perceived, because it is not with blood that they are filled. Even admitting the opening of a living animal were wanting to ascertain this, the surgical operations, in which the intestines are laid bare, and the peritoneum uninjured, wounds of the abdomen, the cæsarian operation, &c. would indisputably prove, that in the natural state the blood only fills the tenth, nay the twentieth part of these vessels in the serous surfaces, when compared with the number their tissue is proved to contain on injection.

Let these surfaces be examined when in a state of chronic or acute inflammations, particularly the former, and they will display a vascular net so completely filled with blood, that their reddish appearance will be found to exceed that of the muscles.

Every organ above-mentioned presents the very same phenomenon. Let us only observe what takes place in the skin; fine injections display in this tissue a much greater number of vessels than are filled with blood in the natural state: the face of an infant, when properly injected, is quite black. Who is not aware that frequently, in consequence of violent passion, the blood will fill in the cheek, with the utmost rapidity, a number of vessels that were not apparent during a state of tranquillity.

Let the tunica conjunctiva, so frequently produced as an example of inflammation, be examined: its whitish appearance is often instantaneously converted into a deep red, because then the blood fills a number of tubes through which it did not previously circulate; these vessels are very distinct to the naked eye; we perceive that the blood circulated in this membrane is contained in vessels, and by no means infiltrated.

By way of example, I shall produce those organs in which the surfaces are not attached, because the state of the capillary system is ascertained with more facility in these, although the others would afford the same phenomenon: we should find the cellular tissue in some of the fibrous organs, &c. &c., when compared, on one part, in animals dissected alive; on the other, in the state of inflammation, or after proper injections, disclose a much smaller quantity of vessels in the former case than in the latter. It may then be established as an indisputable fact, that, in a number of organs of the animal economy, the general capillary system is, in the natural state, partly supplied with blood, and partly with other fluids of a whitish appearance.

The proportions vary considerably. As I have before stated, the capillary system in the serous membranes hardly contain any blood; that in the skin is rather better supplied; the mucous surfaces still better, &c.: but let that connection be what it may, the difference in the capillary system still exists.

There may indeed habitually exist in this system empty vessels, intended, in peculiar circumstances, for receiving fluids: thus, the ureter, the excretory vessels, in some cases the lacteal orifices, during the intervals between digestion are empty. The rapidity with which the blood is conveyed into the capillary tubes of the face, and in those of the other parts of the skin, could hardly be conceived if these vessels contained a fluid to be expelled before the blood can enter: in short, nothing grounded on experience can be produced to resolve the question.

Organs in which the Capillary Vessels contain no Blood.

These organs are not so numerous as the preceding. Such are the tendons, the cartilages, the hair, and a few ligaments, &c.; they are dissected in the living animal without the slighest effusion of blood: capillary vessels, however, exist in these parts: this is ascertained by proper injections. In inflammations they are also frequently filled with blood. In the plica polonica this fluid penetrates the hair; consequently, the non-vascular appearance of these organs in the living subject is illusory; it is because their fluids are divided into such very minute streams, because their circulation is very slowly performed and their colour is different from that of the blood, that they are imperceptible.

SECTION II.

Differences between the Organs relative to the Number of Capillary Vessels they contain.

Although the capillary vessels exist in every part of the body, yet they are found more or less numerous according to the respective organs: however indifferently the fine injections be introduced, they still clearly establish the fact. What anatomist has not been surprised at the prodigious number of vessels displayed by this means in the skin, in serous surfaces, in the cellular tissue, &c., when compared with those it presents in the fibrous organs, even in the very muscles, &c.?

I have sought for the cause of this difference, and had no difficulty in making the discovery; by remarking that wherever a few capillary vessels only were ascertained by injection, the process of nutrition only was carried on: of this, the bones, the muscles, cartilages, and fibrous bodies, afford constant proofs; that, on the contrary, in all organs that admit of many fluids, besides nutrition, other functions, such as exhalation and secretion, are effected. This explains why a serous surface, nearly as white in the living subject as cartilage, acquires by injection a much deeper hue; why the skin, compared to the fibrous organs, displays the same phenomenon: why, again, in proportion to the arteries that enter a muscle, or a gland, this will admit of more considerable injections than the former.

These observations, which are constant, prove that the capillary system is developed in proportion to the functions it has to perform in any part. It forms, in fact, a kind of reservoir, in which the fluids stagnate and oscillate for some time before they serve for nutrition, exhalation, and secretion: whenever these three functions are united, they require more fluid than where one only is performed; hence, there are more capillary vessels.

The capillary system, then, is not proportionate to the size of the organs; a narrow part of the pleura contains more of these tubes than a tendon, which is ten times its size. It is the nutritive substance which fills up the vacancy unoccupied by these vessels.

These systems, with regard to the developement of their capillary vessels, might, in consequence of what I have just said, be divided into two classes: on one hand may be placed the serous, mucous, glandular, dermoidal, synovial, cellular, &c.: on the other, the bony, cartilaginous, fibrous, arterial, veinous, fibro-cartilaginous, &c. The first class, in respect to these minute tubes, far exceeds the second. It may also be remarked, that inflammation, the various eruptions, every affection in short, in which there is an afflux of morbid humours to a part, as is commonly termed, are much more frequently met with in the former class than in the latter, because these affections have their particular seat in the capillary system, which is, in consequence, more developed.

Asphyxia, apoplexy, and every affection that causes the veinous blood to stagnate in the general capillary system, prove the same thing: in fact, if we only examine the livid head of a strangulated or apoplectic subject, we shall find that it was especially in the skin, and in the cellular tissue, where the circulation was obstructed; that the muscles and the aponeurosis contain only a very small quantity of superabundant fluid, in addition to what they habitually possess, when compared with that in the former organs.

Remarks on Injections.

From what has hitherto been stated, it is evident that fine injections, which are so very effectual in elucidating the capillary system in an organ, are of no use whatever in discriminating between the vessels of this system that admit the red blood, and those in which white fluids are exclusively circulated. In fact the injected fluid penetrates both indiscriminately, and what was so very distinct during life, can no longer be distinguished.

To form a precise and correct idea of the quantity of blood that circulates during life in each of these organic systems, it is necessary they should be dissected in living animals. I shall have, in the course of this work, frequent occasions of alluding to, and insisting upon this fact, which in many respects appears to me of the utmost importance. Let fine injections be attended with ever so little success, they still display real vessels, but which did not contain blood during life. Even the coarse injections in our theatres frequently present these phenomena, particularly in the head and neck, &c.; and the more striking if the fluid be fine, and the experiment be dexterously performed. I cannot conceive how physiologists could have continually admitted the state of injected parts as a standard for blood vessels. By opening any part whatever of a living animal, they would have perceived the illusion.

Injections are advantageous in respect to large vessels only, in which the blood is circulated in a mass, under the influence of the heart; they can never completely penetrate the ultimate ramifications of the capillary vessels.

I should recommend, that the pupils in our anatomical theatres, after having regularly dissected the arteries and veins, should be directed, as an end to their studies on this subject, to dissect these vessels in living animals, to enable them to ascertain the quantity of blood each capillary system contains. This is an essential investigation to the study of inflammations, fungous tumours, &c. The museum in which the various preparations are preserved, is of no use in this respect; these parts being the more likely to deceive, in proportion as their preparation has been attended with more success.

SECTION III.

Of the Proportions existing in the Capillary Vessels between the Blood and other Fluids.

In those organs where the white fluids, distinct from the blood, circulate exclusively, there can be no variety in proportions; but these varieties are frequently met with in those where the fluids meet at the same time. In the skin, the serous and mucous membranes, &c., there are sometimes more, sometimes less, of these small vessels filled with blood. The cheeks, as I have just stated, afford a striking instance of this; the slightest emotion, the least agitation, any movement attended with exertion, accumulates, decreases, and changes the quantity of blood in a variety of different ways. The whole surface of the skin displays the same phenomenon, although less frequently. If this organ be irritated in any part whatever, it instantly acquires a redder colour; and if compressed, it becomes whiter. Heat and cold invariably produce similar varieties, if the transition be abrupt, and every mucous surface displays the same disposition. Let us only consider the glans penis, in the ardour of coition, or in the succeeding state, the difference in the quantity of blood contained in its external membrane is remarkably striking. If a serous surface be laid bare, at first white, it soon becomes covered with numerous streaks. If the capillary vessels of the glands could be made visible, I conceive that these minute vessels would be found to contain variable quantities of blood, and that whilst their secreted fluids flow from these organs in abundance, their system is more abundantly supplied than at any other time with that which provides the materials. Why should not the kidneys and the liver, in the same manner as the surface of the skin, be subject to the same varieties in respect to the quantity of blood?

When after violent exertion, perspiration flows in abundance, does not the surface of the body redder than usual, prove that a greater proportion of blood has penetrated the skin?

Two things, however, in this respect, ought to be distinguished. It is only when the abundance of secretions proceeds from an increase of vitality that a greater quantity of blood is admitted into the glandular system. Whenever this increased secretion proceeds from a deficiency of vital energy, there is not a greater quantity of blood in the gland. The same observation applies to exhalation. Thus, in the case above stated, in fever, &c., more blood is conveyed to the skin; but when perspiration proceeds from weakness, as in phthisis for instance, &c., there is an accumulation of blood in the capillary system. This, however, claims a further explanation.

Different Proportions of Blood in the Capillary Vessels from the Active or Passive State of the Secretions and Exhalations.

By active exhalations and secretions, I mean those which are preceded by, and attended with a remarkable degree of vital power: passive exhalations and secretions are such as display a reverse phenomenon. However slightly the phenomena of the animal economy be examined, this distinction, which appears to me of the utmost importance in diseases, will be easily felt. Now let the organ in which it is studied be where it may, every active secretion or exhalation is always preceded by a more abundant determination of blood to the part; every passive exhalation and secretion displays the contrary disposition. We shall begin with the exhalations.

1st. The cutaneous exhalation, as I have previously stated, is active whenever it follows violent exertion, fever, the action of caloric on the body, hard labour, &c.: in these cases the skin is more expanded, of a deeper colour, more blood is conveyed to it, &c. This excitement of the skin renders it more susceptible of being acted upon by external causes, to influence in turn the other organs. It is the suppression of these kind of perspirations that occasions so much mischief in the animal economy. If, on the contrary, the surface of the body be examined during the colliquative sweats of phthisis, during those occasioned by internal suppurations, those produced by fear, and all that are included under the denomination of colliquative, &c. the body will then be found paler than in the natural state; it is not susceptible of being influenced, because its vital activity is then rather low, and its powers in a languid state.

2dly. Amongst the exhalations of serous surfaces, some are essentially active: such is that of pus; for we shall find that the secretion of this fluid in these membranes is attended with no kind of erosion, that it evidently flows from the exhaling vessels in the place of serum; these two fluids even, often flow together. Nothing in fact is more frequent than the milky and purulent serum found in the peritoneum, the pleura, &c., whether it is that these two fluids are exactly mixed together, or that pus is suspended in flakes with the serum. Now this active exhalation of serum or pus, which appears in this case to be coagulated albumine, this exhalation then is evidently preceded by a considerable accumulation of blood in the capillary system; an accumulation that has produced inflammation, and without which the exhalation could not have been performed: if, on the contrary, the increased serous exhalation, proceeding from weakness affecting the organization of the serous membranes, be examined, we shall never find that blood has existed there in a larger quantity to produce the fluid. If the membranous pouches be opened subsequent to the diseases of the heart, to those of the womb, of the lungs, of the liver, of the spleen, &c., they are found filled with water, and still more transparent than in their natural state, because they have received a less quantity of blood.

3dly. What I have stated respecting serous exhalations, ought also to be referred to the cellular; some are active, such as those of pus and of serum that sometimes accompany the former: others are passive, as in leucophlegmacy after organic affections. Now in this case, as in the the preceding, accumulation of blood in the capillary system attends the former, reduction in the quantity of that fluid characterizes the latter. Let us consider the exhalation of fat. A healthy man that is very corpulent, has a rosy colour, that extends over the integuments distended by fat, and denotes an abundance of blood in the capillary system. On the contrary, in peculiar cases of sudden corpulency attended with weakness, and which takes place subsequent to diseases, when the subject is said to be puffed up, a general pale appearance, coinciding with the nature of this swelling, implies a deficiency of blood.

4thly. The mucous exhalations also display a similar phenomenon. I shall afterwards prove that the hemorrhages proceeding from mucous surfaces, are actually exhalations; some evidently are active, a term Pinel has adopted in his nosography: such are, both in the youth and in the adult, the nasal, pulmonary, gastric, and uterine hemorrhages. Now all these, in consequence of the greater quantity of blood that has penetrated the capillary system, are attended with a local increase of action, with increased heat and a deeper colour of the mucous membrane. We are aware, that Galien predicted an hemorrhage, from the redness he perceived on the nose and eye of a patient? If, on the other hand, we consider the hemorrhages of the mucous surfaces subsequent to long diseases, the hemoptysis which terminates diseases of the heart, the hemetamesis produced by organic affections of the liver, the hemorrhages of the intestinal canal, so frequent after long continued organic affections of the large intestines, &c., hemorrhage from the nose, subsequent to peculiar fevers essentially adynamic, those which in scurvy flow from the different mucous membranes, from the gums, &c., all these hemorrhages that are actually passive, are not attended with that previous vascular congestion in the capillary vessels, nor with that increased vital action; we might say, that it is a transudation through the pores, that are no longer possessed of sufficient energy to retain the fluid, similar to that which occurs in the dead body. This distinction is so correct, that without having admitted it in theory, physicians still attend to it in practice. Bleeding is recommended to stop an active hemorrhage, but is it prescribed in cases in which it proceeds from chronic diseases in the chest? The same observation applies to every kind of hemorrhage; accordingly as they are active or passive they require quite an opposite method of treatment; this observation may also be applied to every disease, where there is increased exhalation or secretions, in whatever part it may be seated. It is not the phenomenon that we have to contend with, but the cause that has produced it. When, after pleuritis, serum accumulates in the chest, the powers are to be reduced; they are to be increased whenever it has accumulated from disease of the heart, of the lungs, &c.

What I have stated in respect to the exhalations, must also be applied to the secretions. The mucous glands, in two different cases, secrete a greater quantity of fluid, sometimes from irritation, on other occasions, from a deficiency of power. When this takes place in the intestines, diarrhœa from irritation is the result in the first case, colliquative diarrhœa in the second. Now it appears, that a greater quantity of blood reaches the gland in one instance, than in the other; in the greatest number of acute catarrhs, in which there is an active secretion of mucus, the increase of this fluid cannot be doubted. The circumstance of its decrease, or at least, its remaining stationary, is not less striking in a number of chronic catarrhs, in which secretion may be considered as passive. We are aware, that the quantity of urine and of bile, implies sometimes an increased, at other times a diminished action, in the spleen and in the liver. Is there not also a superabundance of semen from excess of vitality and an unnatural emission from want of power: it is the same with every secreted fluid. Now in these opposite instances of superabundant secretion of fluid, the capillary system of the glands is certainly penetrated with different quantities of blood. Although the phenomenon is the same, yet the treatment in diseases in which it occurs, must, as in the preceding cases, be quite reversed, accordingly as it is produced by an increase or diminution of vitality in the part.

Consequences of the preceding Remarks.

From all that has been previously stated, it is evident, that in every organ in which the capillary system is filled partly with blood, and partly with other fluids, the proportion of the former, with the latter, must vary very considerably; that innumerable causes, as well in health as in disease, by conveying to the organ a greater or less quantity of fluid, may affect the capillary system in a similar manner.

Are the trunks and branches that resort to an organ, more or less dilated accordingly as the capillary system in that organ contains a larger or smaller quantity of blood; for instance, are the adjoining branches more filled when the secretion of the mucous glands is increased? Some experiments I shall hereafter point out, seem to prove it.

SECTION IV.

Anastomosis of the General Capillary System.

All that has hitherto been stated, evidently admits of a free communication between all the parts of the capillary system; such communication in fact, is clearly proved on inspection. When an injected serous surface, whose capillary system is filled, is examined, this system proves an actual net work, in which no vascular thread is continued more than the sixth part of an inch, without communicating with the others. The passage then, between the part that receives the blood, and that which admits other fluids, is constantly free. A similar disposition is ascertained in the dermoïdal system, in the origin of the mucous system, &c., and in general, in all those where the capillary system contains both blood and white fluids.

On the other part, the organs that contain white fluids only, evidently communicate with the adjoining, which receive blood; those in which blood seems exclusively admitted, are disposed in a similar manner.

The capillary system then, must be considered as a general plexus, extended throughout the whole body, communicating on one part with every organ, on the other from one organ to another. There is, in this respect, a general anastomosis from head to foot, and a free communication is opened to the fluids. In this manner, the permeability of the body might be admitted, but not in respect to the cellular tissue, in which fat and serum only are found to stagnate.

As the arteries open into the capillary system, and as this system also gives rise to the veins, to the exhalants, and to the organs of secretion, it is evident, that from this manner of viewing the capillary system, all these vessels must unavoidably communicate; that, in propelling a thin fluid into the arteries, it must, after having overrun the capillary system, flow from the excretory and the exhaling vessels, and be returned through the veins. This, in fact, is actually the case. In this respect innumerable points are constantly left open for the passage of the blood from the vessels, which openings also communicate outwardly with every part, and oppose in their cavities no mechanical obstacle to the blood, which is retained within the limits of its circulation by vitality only. The transudations of the dead body, in the exhalants, the excretory ducts, and the veins, are so well known from the numerous instances mentioned by anatomists, that I think it unnecessary to dwell any longer on this subject. We have seen very liquid injections when poured upon the serous membranes, the pericardium, the pleura, the peritoneum, &c. transude through the mucous surfaces, and even through the skin. They have been seen to flow through the ureters, the pancreatic, biliary, and salivary canals, &c. Haller, in mentioning each organ, never fails to produce a number of these instances, that prove the communication between the arteries and all the other vessels, through the means of the capillary plexus. What anatomist, in fact, has never found even the coarse injections to return through the veins? The communication by means of the capillary system, between these vessels and the arteries, is now an anatomical axiom. It has been much talked of. It has been asked if there is an intermediate agent for the arteries and the veins. Dissection has proved that it exists in the capillary system.

Hence we ought to represent to ourselves the capillary system as a kind of general reservoir, in which the arteries enter on one part, and from whence, on the other part, the exhalants for nutrition pass into every organ, into some of these certain peculiar exhalants, such as those intended to separate the perspiration, lymph, fat, &c.; into others the vessels of secretion, &c. It is, in short, a common reservoir, if I may be allowed the expression, where the red blood is received, and from which the dark blood, the exhaled and secreted fluids, &c. pass out.

This idea is not grounded on supposition. It is fully established by the injections I have just mentioned. It should not be termed a mechanical transudation, similar to that of bile through the gall bladder. If this were the case, not only very liquid injections would unavoidably flow from the execretories, the exhalants, and be returned through the veins; but would also, by penetrating the pores, fill the whole cellular tissue. Nothing, on the contrary, round the vessels through which the injection is conveyed, filtrates into the cellular tissue; then there is a continuity of tubes from the artery that has received the injection to the excretory and exhaling vessels, or to the vein that transmits the fluid.

The communications in the capillary system account for the skin becoming livid in that part on which the corpse has rested for some length of time; in the back for instance: they also explain why, in placing the subject with the head low, this part becomes gorged with fluid; why, on the contrary, by fixing in an upright posture the body of a person that has died from apoplexy or suffocation, the capillary system of the face is actually disgorged of the infiltrated blood; why erysipelas can no longer be traced in the dead body, when the blood fixed, during life, in a part of the skin, is disseminated after death throughout the surrounding parts; why every similar redness of the skin, and even of the serous surfaces should disappear because the blood proceeds through the communications in the capillary system to the adjoining organs. During life, this fluid is retained by the tonic power in a particular part; after death, being subjected to the laws of gravity and to other physical causes, it soon, in consequence of the innumerable communications existing in the general capillary system, disappears from the part in which it had accumulated.

To those who examine the dead body, I recommend these considerations as worthy of the greatest attention. Thus no calculation can be made respecting the quantity of blood that penetrates the pleura or the peritoneum in a state of inflammation, by that found twenty-four hours after death; local irritation was a permanent cause that determined the blood to the part, and this cause no longer existing it consequently escapes. A serous membrane may have been considerably inflamed during life, and present nearly a natural aspect after death; it is the very same thing as in erysipelas. I should frequently, on dissection, have been induced to pronounce the non-existence of an affection that had actually taken place. The same remark is applicable to the cellular tissue and mucous surfaces affected with inflammation. If we only examine a subject who has died in consequence of angina pectoris, which, during life, had tinged of the deepest red, the arches of the palate, the palate itself, and the whole of the pharynx, we shall find, that, subsequent to death, the parts have nearly re-assumed their natural colour.

I shall observe, in this respect, that the acute affections ought to be distinguished from the chronic; for instance, in chronic inflammations of the pleura, of the peritoneum, &c. the colour, after death, remains the same, because the blood has in some measure been combined with the organ; it forms, as it were, an integral part of it, as it does in muscles in their natural state. In the same manner the chronic affections of the skin, of the mucous surfaces, retain, after death, nearly the same quantity of blood they were possessed of during life, whilst, in acute affections, the blood having been retained by the irritation escapes the moment life, which is connected with this irritation, has ceased. These principles admit also of being applied to a variety of diseases. I again repeat, they are of the utmost importance in dissection. The neglect of them at one time frequently led me into error, in respect to the intensity, and even the existence of acute inflammations, that had existed in the organs I was then examining.

SECTION V.

Why, notwithstanding the general Communication in the Capillary System, the Blood and other Fluids remain separate.

Since in the corpse, and consequently during life, there exists in the capillary system no organical obstacle to the fluids that communicate through its minute tubes, and the general plexus formed by these vessels is free in all its parts, how happens it that the blood never enters those intended to contain the white fluid; that these fluids never enter vessels in which blood circulates? Why does not blood flow from the exhalants, the excretories, &c., since these tubes have direct communications with the arteries, through the anastomosis of the capillary system? This proceeds entirely from the connection that exists between the organic sensibility of each part of the system and the fluid it contains. Those which contain the blood are irritated by other fluids which, on approaching, cause them to contract, and by a similar cause the blood cannot enter the other vessels. Why does the trachea admit of air only and reject other fluids? Why do the lacteals select chyle only amongst the intestinal matters? Why again are these substances never admitted into the excretory vessels that open into the intestines? Why, in short, does the skin exclusively absorb peculiar substances, and not admit of others, &c.? All this depends upon each part, each portion of an organ, each organized particle in short, being in some measure possessed of its peculiar mode of sensibility, which is connected with one substance only, and rejects the others.

But since this mode of sensibility is liable to vary, its connections with the substances foreign to the organ also varies; thus a part of the capillary system, that has rejected blood, will admit of this fluid from the moment its sensibility has been excited. If any part of the skin be irritated it instantly becomes redder, the blood is determined to it, and as long as irritation is continued it remains in the part, and retires when the cause ceases. Whatever may be the external agent that excites the cutaneous or mucous sensibility, the phenomena is the same. In this respect we have the power to determine more or less blood to any part of the capillary system. If the hand be placed near the fire, caloric will increase the sensibility of this system, and a larger quantity of blood is admitted; by withdrawing it this property is restored to its natural type, and the blood distributed in the usual proportion. The capillary system of the internal organs being less exposed to the causes of excitement, is not so liable to variations; many, however, are still observed, all of which arise from the same principle.

A continuation of organized vessels cannot then be compared to an assemblage of inert tubes; the latter require mechanical obstacles to prevent the it ermixture of the fluids: where there is a communication between the tubes, communications between the fluids must also naturally exist. In the living economy, on the contrary, it is the vitality of the tubes that forms the obstacle, and draws the line between the different fluids. This vitality fulfils the purposes of the different machines we place between communicating tubes to separate them from each other. Every organized vessel then is essentially active, it will either admit or reject the approaching fluid according to its susceptibility. The varieties in capacity have no connection with this phenomenon; that of a vessel might be four times larger than the particles of the fluid it rejects, if this be repugnant to its sensibility. It was in this respect that Boerhaave's theory proved so very deficient.

At the time this author published his work, the vital powers had not been analysed. Physical powers were unavoidably produced to explain vital phenomena: hence the reason why his theories were as incoherent. In fact, theories borrowed from this source to explain the vital phenomena, would prove as deficient as the vital laws would be inapplicable to those of natural philosophy. What should we think of irritability and sensibility being set forth to explain the revolutions of planets, and the courses of torrents? We should smile at the idea; so must we if, to explain the animal functions, we should resort to gravity, impulsion, variety in capacity, &c.

It is worthy of remark, that the physical sciences had made no progress until the simple laws that govern their innumerable phenomena had been analyzed. The same remark applies to medicine and physiology, which had no real grounds for their explanations, until the vital powers had been analyzed, and produced in every instance as the principles of phenomena. Let us only observe how readily all those of secretions, exhalations, absorptions, inflammations, capillary circulations, &c., return to the same principles and flow from the same source by tracing each to their natural cause, in consequence of the various modifications of sensibility in the organs commissioned to perform them. On the contrary, let us observe the difficulties attendant upon each, when mechanical causes only were produced for their explanation.

From what has been stated above, it is, then, evident, that, in the numerous varieties of fluids of which the capillary system is susceptible, in regard to the different parts of this system, which they fill, there are always antecedent variations in the sensibility of the vascular parieties, and it is from these varieties that the former proceed.

It is in the capillary system especially, and in its circulation, that the varieties of organic sensibility in the vessels produce varieties in the course of the fluids; because, as I have already observed, in the large arteries and veinous trunks, in the heart, &c., the fluids are united into too considerable masses, and moved by a too powerful impulse, to admit of being thus submitted to the influence of the vascular parieties. Thus, when nature intends to prevent the fluids from communicating in the trunks, she has provided them with valves, or other similar obstacles, situate between them, which would be of no use in the capillary system.

Although the anatomical disposition is the same in the dead and in the living subject, there is evidently a material difference in the latter, in respect to the course of the fluids through the capillary system. If different thin fluids be injected through the aorta, after having destroyed life, by opening that artery to adapt a cock to it, they are never seen to fill the capillary system, to shower from the exhaling, the excretory vessels, &c., as occurs when the subject has been for some time deprived of life. The organic sensibility of the part, repels the injection; this fluid can only circulate in large trunks that afford considerable space. I have frequently injected, although with other views, both the arteries and veins, but have never seen the capillary system admit of the fluids; they circulate in the large vessels only, when the animal can bear them. Buniva has also made comparative experiments by injections both of living and dead animals; in the former he found a degree of resistance not existing in the latter. Now this resistance is in the capillary system, whose tubes reject a fluid not suitable to their organic sensibility.

SECTION VI.

Consequences derived from the preceding Causes, in regard to Inflammation.

From what has hitherto been stated, we may easily conceive what takes place in the phenomena of inflammation, when considered in a general point of view.

If a part be in any way irritated, its organic sensibility is instantly altered and increased; the capillary system, hitherto unconnected with the blood, receives and attracts it, as it were: this fluid flows to the part and there accumulates, until its organic sensibility has been restored to the natural type.

The capillary system, being impregnated with blood, is then a secondary effect of inflammation. The principal phenomenon that produces the others is the local irritation that has caused a change of organic sensibility. Now, this local irritation may be produced in various ways:

1st. By the direct application of an irritating substance,—as a straw to the tunica conjunctiva; cantharides to the skin, by offensive emanations, spread over the mucous surfaces of the bronchiæ, or in the fossæ nasales; by atmospheric air when in contact with any internal organ laid bare,—in wounds, for instance, &c.

2nd. By a continuity of organs; for instance, as when a part of the skin, the pleura, &c., are inflamed, the adjoining parts will also become affected, and the course of the blood is directed in the same manner as when an organ is diseased, and the next partakes of the morbid state, through the medium of the cellular communication.

3rd. By sympathies: thus when the skin is chilled by cold, the pleura becomes sympathetically affected; its organic sensibility is increased, and the blood rushes to it from every direction.

If this property be affected in the capillary system by any of these means, the resulting phenomena will be exactly similar; for instance, if it be increased in the pleura, either because, from a wound in the chest, the air is admitted to the membrane, or because the lungs it envelopes have been previously affected, or finally, because the skin has been chilled when in a state of perspiration; the consequence is nearly similar in respect to the approach of blood in the capillary system.

It is, then, the change that occurs in the organic sensibility that constitutes both the essence and the principle of the disease; it is this change that produces more or less pain in the affected part: sensibility, at first organic, becomes animal; the part was previously sensible to the impression of blood, but did not convey that impression to the brain. In this last instance it does, and that sensation is painful. If in a living animal the pleura, in a healthy state, be irritated, it gives no signs of pain; but if this membrane, on the contrary, be irritated when inflamed, it will produce the most acute pain. Are we not perfectly aware, that, in general, more or less pain is felt in an inflamed part before it becomes red? Now this sensation bespeaks a change of organic sensibility; it may even exist some time without producing any effect: this, which is owing to the afflux of blood, is consecutive.

It is the same in respect to heat. I shall state hereafter how it is produced. It is sufficient here to say, that, similar to the passage of the blood in the capillary system, a consequence only of the organic sensibility. Now, this is evident; since in every case it is subsequent to this change.

The very reverse, then, to what Boerhaave had supposed takes place in inflammation. In fact, according to this author, the blood accumulated in the capillary vessels, and propelled by the heart *a tergo*, as he used to term it, was the actual and immediate cause of inflammation, whilst, from what I have stated, it is only the effect.

However little we reflect upon the innumerable causes that may alter the organic sensibility of the capillary system, the astonishing variations of which inflammation is susceptible, may be easily conceived, from the momentary flush in the cheek, in consequence of the capillary system being either directly or sympathetically influenced to the extreme degree of phlegmon, or erysipelas.

In respect to inflammations, a scale of intensity may be formed. In taking the cutaneous inflammations for an example, we shall find, at the bottom of the scale these flushes, which come and go from the slightest external irritation of the dermoïdal system, in which there is merely an afflux of blood, and which may in this respect be produced at will; then, those rather more intense, producing cutaneous efflorescences, and lasting a few hours only, but unattended with fever; then again such as are attended with some fever, that are formed and disappear in the course of a day; afterwards the erysipelas of the first order; then, such as are more intense, up to those which soon terminate in gangrene. All these various degrees do not imply a difference in the nature of the disease; the principle is every where the same: there is constantly—1st. A primary increase of organic sensibility, or an alteration in that property; 2nd. Afflux of blood only if the increase be slight; afflux of blood, heat, pulsation, &c., if more considerable, &c. In regard to fever, it is a general phenomenon in every acute local affection that is rather intense; it seems to proceed from the singular connection that binds the heart with all the parts, and has, in inflammation, nothing peculiar but the particular modification it admits of.

The afflux of blood is produced in inflammation in the same manner as it is on incision. In the latter case the divided point has been irritated by the instrument; blood instantly flows from the surrounding parts, and issues through the wound. This afflux is so evidently a result of irritation, that in a slight cut scarcely any flows at the moment the integuments have been divided, because little of that fluid only was contained in the divided part, but soon after irritation will produce its effect, and the blood flows in a quantity quite disproportionate to the incision.

When the alteration in organic sensibility that produces inflammation varies in intensity only, the inflammation itself differs only in degree. The nature of the alteration, however, is frequently different, being often a typhoid character superadded; the heat of the part is less, the colour lighter, &c. Other modifications also are remarked, but they all proceed from the differences in the alterations of the organic sensibility; at least, these alterations are always primary.

The influence of these alterations is not less striking when inflammation subsides, than when it is produced; if organic sensibility has been increased to such a degree as to be exhausted as it were, then the solid dies, and the fluid being no longer contained in a living organ, soon undergoes putrefaction. Let us only study the phenomena in cases of gangrene; putrefaction is undoubtedly always consecutive. We shall always find; 1st. That the solids have lost their vital powers; 2dly. That the fluids have yielded to putrefaction; the former circumstance never succeeds the latter. When organic sensibility begins to fail, the blood, induced by inflammation, may readily putrefy, but putrefaction is always preceded by a deficiency of power in the solids. This local affection is the same as the general one in fevers of a typhoid type. It cannot be denied that in these fevers the blood has a tendency to decomposition and putrefaction. I shall go further. I will say, that this fluid frequently displays the first degree of dissolution. Now the indication of this change is constantly the general state of the powers and the solids; they first loose their energy; symptoms of debility appear before those of putrefaction. Every animal fluid has a tendency to putrefy; this is unavoidable whenever life has forsaken the solids through which they circulate. This tendency then may gradually increase as the solids are divested of their powers. The first degrees of putrefaction of the fluids during life then, is not more unlikely as a general occurrence than as a local one. We have stated, namely, that the blood in an inflamed part begins to be putrid, and the part consequently to become fetid, before organic sensibility has completely left the solid.

It is only after this property has forsaken the part that the process of putrefaction is completed; but then its progress is very rapid, because it had began during life. In the same manner will the bodies of those who have died from fever be more rapidly decomposed than such as have perished from other diseases, because putrefaction had actually begun before death.

Inflammations that are attended with a livid hue, a slight degree of heat, prostration of powers in the part, and, finally, gangrene, are evidently very characteristic of adynamic fever, as phlegmon is with regard to inflammatory fever, irritation in the gastric organs, called bilious disposition, in respect to the meningo-gastric fever, &c. I believe, that if local affections and fevers, generally speaking, were properly studied, a kind of fever, corresponding in its nature to some local affection, would always be met with. But let us return to inflammation.

If this affection terminate in suppuration, it is evident there exists again a different change of organic sensibility to produce pus. In induration there is a similar phenomenon. When it terminates by re-solution, it is because this property has returned to its natural type. If all the phenomena of inflammation be accurately investigated in succession, we shall find, that in every instance a peculiar state of this property always precedes the changes that take place.

When medicaments are applied to an inflamed part, it is not upon the blood they act; nor is it by reducing the degree of caloric, or by relaxing the parts. The words, *to soften, to distend, and relax* the solids, are incorrect, because they are borrowed from natural philosophy. A dry hide may be softened by being steeped in water; but living organs can only be acted upon by modifying their vital properties. We may remark, that although the influence of these powers begins to be admitted in diseases, yet the medical language made use of to explain the morbid phenomena, is still completely borrowed from theories that are derived from physical principles. We have reached a period when the mode of expression in respect to these phenomena requires to be altered: by this I do not allude to the names of diseases. All emollient, astringent, resolvent, relaxing, strengthening, &c. remedies, applied with different views on an inflamed part, have certainly no other effect than to modify, in different ways, the organic sensibility. Thus it is our applications will either cure, or frequently aggravate the disease.

From all that has here above been stated, it is evident that the solids act the most essential part in inflammation, and that the fluids are only secondary. Modern authors have perceived this truth very forcibly, and have instantly allotted to the nerves an essential part in this respect; but we have seen these organs do not seem to be connected with organic sensibility. This is ascertained by the most careful observations; the nervous power, at least such as we observe in other parts, has, in inflammation as in secretion, exhalation, and nutrition, scarcely any influence. In this affection there is a change in organic sensibility, and nothing more.

The species of blood varies in inflammation; and in this respect we might, I believe, lay down what follows as a general rule: whenever organic sensibility is excessive, and attended with an increase of vitality in the part affected with inflammation, it is the red blood that stagnates in the capillary system, and the degree of heat is much increased. When inflammation, on the contrary, approaches the typhoid character, the part is dark and livid, the capillary vessels are filled with dark blood, and the temperature is much reduced. In general, a lively hue, florid, in every kind of eruption analogous to inflammatory tumours, denotes an increase of organic sensibility. Every livid aspect, on the contrary, bespeaks its deficiency: petechiæ and scorbutic spots are livid. In tumours, a livid hue always precedes gangrene. If we are desirous to know when cold acts as a stimulant? It is when it reddens the nose, ears, &c. When these parts become livid, other phenomena at the same time denote its action to be sedative. This corroborates my experiments respecting life and death; in which I have ascertained, that the dark blood interrupts every function, weakens, and even interrupts motion in the parts whenever it is conveyed through the arteries.

Varieties of Inflammation according to the different Systems.

From what has been said in respect to inflammation, it appears to be seated in the capillary system, and consists principally in the alteration of the organic sensibility of this system, producing a determination of blood to vessels that did not previously receive it, and consequently an increase of caloric, &c. Wherever then the capillary system predominates, and the organic sensibility is more striking, inflammation must be more frequent, which is really the case. This affection is most common in the cellular, serous, mucous, and dermoidal systems, and in these very liquid injections display an intricate plexus of capillary vessels much superior to that of the other systems. On the other hand, as not only nutrition, but also exhalation, and frequently secretion, take place in these systems, they naturally require more organic sensibility, a property from whence all these functions are derived.

Inflammation, on the contrary, is seldom met with in the muscular, bony, cartilaginous, fibrous, arterial, and veinous systems, &c. where there are but few capillary vessels, and in which organic sensibility, presiding solely over nutrition, must unavoidably exist in a less degree.

As the capillary tubes form also an integral part of the systems in which they are situate, and every system is possessed of its peculiar mode of organic sensibility, it is evident, that their respective sensibilities must partake of this mode, and as it is on this property all the phenomena of inflammation revolve, they must in each system present quite a different aspect. Of this we shall have frequent opportunities of convincing ourselves when viewing each system; at present, it will be sufficient to trace the general outlines of this essential point on which authors have not insisted.

Let us begin with the systems that are most liable to inflammation; we shall find, that phlegmon is the inflammatory mode of the cellular, erysipelas of the dermoidal, and catarrh of the mucous system. We have not yet adopted a general denomination to express that of the serous membranes, yet we are fully aware how much it differs from the others.

In systems that are seldom affected with inflammation, it is by no means so well known as in the preceding; but that there is an essential difference cannot be doubted. Let their duration and stability in the bones be compared with their rapidity and mobility in muscles, or rather in fibrous bodies, affected with rheumatism.

The effects of inflammations are as variable as their nature; if resolution do not ensue, each has its peculiar mode of suppuration. Let us only compare together the pus in erysipelas, that of phlegmon, the milky or slimy humour of the serous membrane, the whitish or greyish matter of the consistency of mucus, proceeding from that membrane subsequent to catarrhs, the dark sanies flowing from bones in a state of suppuration, &c. &c., we shall find that some organs do not suppurate as fibrous bodies.

When gangrene has taken place, it is every where the same, since it only consists in the absence of life, and all dead organs have the same properties. But according to the degree of organic sensibility each organ is possessed of, that organ is more or less inclined to be destroyed by inflammation in the midst of others that retain their vitality. Who is not aware that the carbuncle, which soon produces death of the parts where it exists, is confined to peculiar systems; that the bony, the cartilaginous, the nervous systems, &c. are never affected with it, &c.?

The chief error of every medical doctrine, is to consider diseases too abstractedly; they are in every system modified in so many different ways, that their appearance is quite different. Let me be allowed this expression; it is, in fact, the same individual, but assuming a different mask according to the organs he invades, so that he cannot be recognized. When will medical science have made sufficient progress for the treatment of diseases, to coincide with these varieties? A general treatment is certainly required in inflammation; but it should be differently modified, accordingly as it is intended for phlegmon, erysipelas, catarrhs, &c.

What follows is a convincing proof of the peculiar character inflammation assumes in each part. The facility and rapidity with which the blood flows in a determined part of the skin, in consequence of any irritation whatever, is sufficiently known; if a part be pricked or rubbed it immediately becomes red, which is also the case in mucous surfaces, although in a less striking degree. This, however, is not equally observable in the serous membranes, as I have repeatedly ascertained in living animals, in which I laid these surfaces bare, to irritate them in various ways. The afflux of blood was never immediately subsequent to the irritation; there was always a greater or less interval between the two; the least included a full hour.

SECTION VII.

Structure, Properties of the Capillary Vessels.

WHAT is the structure of the capillary vessels? Such is their tenuity, that in this respect we can certainly state nothing grounded on experiment and open to inspection. It is highly probable however, it is even certain, that this structure is differently modified in each organ; that it is not the same in tendons, aponeurosis, muscles, &c.; that this tissue really partakes of the nature of the organ, of which it actually forms an integral part.

The membrane that lines the excretory vessels, the arteries, the veins, the exhalants, &c., vessels that either resort to the capillary system, or arise from it, is actually similar to that of these capillary vessels, but undoubtedly it is not the same.

It is the diversity of structure of the capillary vessels, that, according to the organs in which they exist, essentially influences the distinctions of the vital properties, organic sensibility, and insensible organic contractility in particular; hence the peculiar modifications in every disease over which these properties preside, and which are seated particularly in the capillary vessels, as inflammations, tumours, hemorrhage, &c.

The varieties of structure in the capillary system are sometimes perceptible to the naked eye. Thus the spleen and the hollow organs, instead of displaying, as the serous surfaces, a vascular plexus, through which the blood is moved in different directions, according to the impulse received, merely present a spongy lamellated tissue, the nature of which we are not yet perfectly acquainted with, and in which the blood seems to stagnate instead of being circulated, &c.

SECTION VIII.

Circulation in the Capillary Vessels.

There are two circumstances connected with the circulation of this system; 1st. The motion of fluids; 2dly. The changes they undergo.

Motion of the Fluids in the Capillary System.

These fluids consist of; 1st. The blood; 2dly. Other fluids differing from this in their composition, although we can form distinctions from their appearance only. Let us examine the laws that regulate the motion of each.

When the blood has entered the capillary system, this fluid is evidently no longer under the influence of the heart, and is circulated only by the tonic powers or insensible contractility of the part; however slightly the phenomena of the capillary system are examined, this fact, which Bordeu first promulgated, will be easily felt. The influence of the heart ceases at the capillary system; hence the reason, why the motion of the fluids in all vessels arising from this system does not correspond with that in the vessels that resort to it.

1st. This, from what we have stated, cannot be doubted in respect to the veins.

2nd. Nor is it less real in regard to the excretory organs.—The increase of the secretions does not coincide with the increased action of the heart, nor their decrease with that of the motions of this organ. On the contrary, are we not aware that, in violent fevers, where the arterial blood is violently agitated, that the glands cease to secrete.

3rd. It is the same thing with the exhalants: it is not when fever is at the acme that perspiration is the most profuse; on the contrary, it is towards its decline.

Hemorrhages are evidently nothing but exhalations: for we know that the pulse is excessively low whilst the blood flows in abundance from the mucous surfaces, from the womb, the fossæ nasalæ, from the bronchiæ, &c. On the contrary, we are aware that the blood does not flow from the exhaling vessels during the most violent exertions of the heart. Is the acceleration of the pulse increased during the periodical discharge?

A plethora of the capillary system, as I have stated frequently, precedes active hemorrhage, but there is never an increase of the action of the heart. The fungous tumours and flabby granulations that arise from unhealthy wounds, polypi, &c. emit blood; but the heart has nothing to do with such hemorrhages, which evidently proceed from the capillary vessels. Are we not convinced that frequently, when the exhalants pour out a great quantity of serous fluids on the membranes of this description, the heart, like every other part, is, in respect to its action, perfectly inert?

Since, then, all the vessels arising from the capillary system afford no kind of harmony in their motions with those of the heart, it is evident that the influence of this organ over the circulation of the fluids terminates in the capillary system. Let us only consider nutrition: it is, undoubtedly, the capillary system that distributes to every part the materials it has received from the impulse of the heart; but the influence of this organ is not extended to the part where the nutritive substance is deposited. In fact, its impulse, every where equal and uniform, propels the blood with nearly an equal degree of energy to all the parts, admitting some exceptions in respect to the fœtus, and which have already been noticed. Nutrition, on the contrary, is excessively variable; particular parts being developed at different periods, and receiving consequently more nutritive substance at another, it is a different organ. This variety is the first and most essential phenomenon of growth.

How, also, could the formation of tetters, of various eruptions, &c. that arise in particular parts, be reconciled with the sole and uniform impulse of the heart? Would inflammation display such varieties in its nature, according to the system affected, if produced by the action of the heart only? All the distinctions between catarrh, erysipelas, phlegmon, &c., would disappear; none would exist, but what take place either more or less in the vicinity of the heart.

Let us, then, cease to consider this organ as a sole agent, presiding over the circulation of the large and the small vessels; as conveying the blood in large quantities into a part, and giving rise to inflammation; as producing by its impulse the various cutaneous eruptions, the secretions, exhalations, &c.: the whole doctrine of mechanicians rested, as is well known, on the very extended motions that were attributed to the power of the heart.

In respect to circulation, there are evidently two classes of diseases: 1st. Those which disturb the general circulation; 2nd. Those which affect the capillary vessels. The different fevers evidently form the first class; the different eruptions, tumours, inflammations, &c. the second: but although numerous circumstances connect the latter with the former, it does not essentially proceed from it, as the following lines will prove. Fever can evidently take place only in animals possessed of large vessels, in those in which the blood is circulated in a mass; it does not therefore occur in the zoophytes and plants that possess a capillary circulation only: these inferior classes of animals, however, and all vegetables, are liable to every affection that is seated in the capillary circulation; thus we find a number of tumours formed on plants; thus their wounds unite; two parts of the same contract adherences, which is proved by ingrafting. Such diseases as are seated in their capillary system certainly differ from those of animals, both in their course and nature; but they continually display the same general character, because they proceed from the same properties, namely, from organic sensibility and insensible contractility.

Since the diseases of the capillary system are not essentially connected with those of the general vascular system, they do not therefore arise from them. Circulation in the first is indirectly subordinate to that of the second;—hence the reason why the two circulations may be divided; why more than the half of organized beings are possessed of a capillary circulation only. This is the most important, since it directly conveys the materials for nutrition, exhalation, and absorption, and is also met with in all organized beings. We cannot conceive any without it, because none can be conceived that are not constantly composed and decomposed by the process of nutrition.

In consequence of all that has been hitherto stated, it is evident that the blood on reaching the capillary system is no longer circulated but by the tonic influence of the solids. Now, as the slightest cause will alter or change their properties, it is liable in this circulation to experience a number of irregular motions. The slightest irritation will make the fluid retrograde or advance—deviate to right, to left, &c. In the natural state, its motion is generally uniform from the arteries to the veins; but it is every moment exposed to meet with causes of irregular motion in its extensive anastomosis;—this proves, as we have seen, that anastomosis could not be dispensed with. These irregular oscillations in the motion of the capillary circulation are perceptible to the eye when assisted with the microscope. Haller, Spallanzani, and others, have frequently observed them in their experiments, which are too familiar to need repetition. In animals possessed of red and cold blood, in which subjects they had irritated the mesentery, or any other transparent part, they have seen the globules move forwards and backwards, and in a number of contrary directions. In animals possessing red and warm blood,—even in those in which the mesentery is nearly as transparent as in frogs; in young Guinea pigs, for instance, it has appeared to me, that to trace the motion of the blood in the capillary vessels is infinitely more difficult.

It is easily perceived, however, that all the phenomena of inflammation in the different eruptions, in tumours, &c. are especially grounded on the facility with which the blood in the capillary system may flow in a great variety of direcions, according to the parts to which it is determined by irritation.

From what has hitherto been stated, it is evident, that sometimes the blood moves slowly through the capillary system; that at other times it is circulated in these vessels with more rapidity; how then can the connection, constantly the same between the arterial and veinous circulations, be accounted for? It is thus. These irregular oscillations seldom take place but in a particular part only of this system; in no case whatever is the whole mass disturbed; thus, if the circulating fluid be but gently moved in the capillary system of the skin, it will circulate with additional rapidity in those of the cellular membrane, muscles, &c. Such, in fact, is an invariable law in the vital powers, that if their energy be increased in one part, it is reduced in another. It might be said, that there is only a certain quantity in the whole economy which may be distributed in different proportions, but is never increased or decreased in the sum total. This principle is so evident a result of all the phenomena of the economy, that I consider it unnecessary to bring forward proofs in support of it. Now admitting this as an indisputable fact, it is evident that when, in any part whatever of the capillary system its action is increased, at the expense of the other parts, the whole mass of blood, transmitted by the arteries to the veins, always remains nearly the same. Every system, then, acts, as it were, in this respect, as an auxiliary to another. If nothing be conveyed through the capillary tubes of the one, it is of no consequence if the vessels of another transmit twice the quantity of fluid compared with that in their natural state.

If we consider the blood in the capillary vessels of the skin, previous to the accession of intermittent fever, it has forsaken these vessels as it were; the surfaces, previously coloured, become pale, but the capillary vessels of the other systems make up for the temporary deficiency. Who can tell if, under numerous circumstances in which the skin is highly coloured; if, when this membrane is permeated with a large quantity of blood, there is not in the other systems a paleness analogous to that of the skin, during the cold fit of fevers? I not only consider this as highly probable, but even do not suppose it admits of a doubt. The external capillary vessels certainly contain more blood in the summer season, whilst those of the internal organs receive more of this fluid in winter. There are, then, constant varieties in the mode of circulation through the general capillary system; each system transmitting, in turn, more or less of this fluid accordingly as it is affected.

When we see the glands frequently secrete in a very short space of time a considerable quantity of fluid, and those of the serous, cutaneous, and mucous exhalants, &c., are much more abundant than in the natural state, we are surprised how circulation can at the same time be carried on with the same precision; and not less so when, on the contrary, we find all the evacuations suppressed, the animal solids secreting nothing: now, in all these cases, it is the capillary system whose powers, variously modified in the different parts, re-establish the general type, which would unavoidably be lost if the heart were the impulsive agent that expels the exhaled and secreted fluids, and propels the dark blood in the veins.

Sometimes, however, almost a general derangement takes place in the capillary system, particularly on the surface of the body; it is caused by the sudden changes of the atmosphere; although the vital laws actually preside over capillary circulation, yet the degree of compression from the surrounding air may, in some measure, modify this circulation: this is proved by cupping, or by any other means that produce a sudden vacuum upon the body; the fluids then pressed in the surrounding parts by the external air, which does not act upon that on a level with the cupping-glass, raises and considerably distends the skin. Sudden changes in the atmosphere will produce over the whole body, although in a less degree, the effect of cupping. If the air be rarefied, the whole external capillary system becomes fuller; the veins, even the sub-cutaneous ones, enlarge, and a considerable part of the blood experiences a disturbance in its motion between the arterial and veinous circulations. The harmony that exists between these two systems is obstructed; hence, weariness, the sensation of heaviness, &c., from which we are instantly freed by a change of atmosphere.

Evacuation of blood will also, although not precisely in so striking a degree, establish distinctions in the capillary system. There are two methods of bleeding: the one reduces the mass of blood in the circulation of the large trunks, sometimes it is the red blood, as in arteriotomy, but more generally it is the black that is drawn. The other extracts the blood from the capillary circulation; it is performed by the application of leeches, the cupping-glass, &c.; either will produce a different change in the course of the blood. Physicians in former times were engaged in considering which vein should be punctured. I believe it would be much more important to know when bleeding should be directed to the general circulation; or when, on the contrary, it should act on the capillary system.

In numerous cases of local obstruction, it does not follow that we reduce the quantity of blood in a part of the capillary system by diminishing the mass of this fluid in the large trunks, admitting even there is a fourth part less in the economy. If a part has been irritated, the same quantity will flow to that part. On the contrary, if we double, by transfusion, the quantity of blood in an animal, local inflammations will not ensue, because, to occasion a flux of blood in a particular part of the capillary system requires a previous irritation.

The fluids distinct from the blood, that are circulated in the capillary system, 1st. Are like that evidently independent of the influence of the heart. 2dly. Their motion is governed by the tonic powers. 3dly. These are, consequently, liable to undergo irregular oscillations, accordingly as the capillary vessels are differently affected.

We are ignorant of the greatest part of these fluids, because it is impossible to submit them to our experiments. It is with these, that the ligaments, tendons, aponeurosis, hair, the cartilage, fibro-cartilage, part of the serous, mucous, and cutaneous surfaces, &c., are permeated: they communicate with the blood from whence they arise in the capillary systems, and are then circulated in their own. In the greatest number of organs where they exist separately, as in those called white organs, the progress of their motion is very slow, because sensibility in these organs is very obscure and languid. Thus, the different tumours they contribute to form nearly always display, as we shall perceive, a chronic course.

In the animal economy those tumours, commonly called lymphatic, are frequently met with, although we are completely unacquainted with the fluids by which they are formed. They are generally produced near the articulations; but these white tumours are sometimes seated exclusively in cartilages, in the cellular tissue, in bones, &c. To ascertain the characters by which these are distinguished, and those in which blood is chiefly admitted, would be very advantageous.

Phenomena of the Changes that the Fluids undergo in the Capillary System.

We have just been examining the phenomena respecting the motion of fluids in the general capillary system: let us now consider the changes they undergo in this system.

The blood displays an important phenomenon in the general capillary system: from red, as in the arteries, it is converted into black. How is this phenomenon produced? It can only take place in two different ways, namely, either by an addition, or by a subtraction of principles. Is it loaded with hydrogen and carbon? or does it only divest itself of oxygen in the organs? Are these two causes united to produce this change of colour from red into black? I believe it will hardly ever be possible to resolve these questions that do not appear to me to admit of being submitted to any positive experiment. However, as the arterial blood supplies all the organs with the materials for secretion, nutrition, and exhalation, it is to be presumed it deposits rather than borrows from these organs the principle of colour.

Sometimes the red blood flows through the capillary system without losing its colour; for instance, when dark blood has for some time continued to flow from a vein, the current sometimes becomes red, or nearly so. I have myself twice ascertained this fact, which I believe has been indicated by some authors.

The blood acquires, in the general capillary system, more or less of a deeper colour. If the flow of blood has been at all regarded, the varieties of colour in the stream flowing from the vein must undoubtedly have been observed in diseases. Does this fluid flow from each part of the capillary system with different shades of colour? It never appeared to me that there is any material difference in this respect. I have had frequent opportunities of opening the veins of the kidneys, the saphenæ, jugular veins, &c., and the blood has appeared to me every where nearly the same. I was anxious to ascertain whether that returned from an inflamed part was more or less dark, and I have consequently made several incisions close to each other in the posterior limb of a dog, and left them exposed to the air: after three days the inflammation being apparently at its height, I have opened the saphenæ, and the crural veins above, both in the diseased and in the sound limb, in order to compare the blood, but could perceive no difference. A short time ago, I caused a man to be bled who had a whitlow, attended with an inflammatory abscess extending over the hand and the lower part of the fore arm: the blood appeared to me of the natural colour; but as the veins also return the blood from the sound parts, this would require more accurate investigation.

One object that should be ascertained with accuracy, is the change that takes place in general diseases in the deep colour of the blood, and the symptoms with which particular alterations coincide. Our investigations have hitherto been restricted to ascertaining, that in some cases it is darker, and lighter in others.

SECTION IX.

The Capillary Vessels considered as the Source of Heat.

Every one is acquainted with the innumerable theories set forth by certain physicians (mechanicians) respecting the production of animal heat. Modern chemists, in proving the insufficiency of such theories, have substituted another, attended with no less difficulty. The lungs have been considered by these as the focus from whence heat proceeded; and the arteries as tubes that serve to convey it throughout the body. According to this the production of this important phenomenon belongs exclusively to the capillary system of the lungs. I believe, on the contrary, I have even professed, in my Lectures on Physiology, and also maintained, before I commenced lecturing, that it takes place in the general capillary system.

I will not stop here to refute the hypothesis of the chemist. When we place on one side all the phenomena belonging to animal heat, and this hypothesis on the other part, its insufficiency to explain them is so very obvious, that I believe every regulated mind may perceive it without being directed. The following are these phenomena.

1st. Every living and organised being, either animal or vegetable, is endowed with a degree of temperature peculiar to itself.

2nd. In animals, this temperature is nearly the same at every stage of life.

3rd. It is completely independent of the temperature of the atmosphere, remaining the same in the midst of a warmer or a colder medium.

4th. In the state of health caloric is frequently more abundant in some parts than in others.

5th. In inflammation there is evidently more local heat.

6th. The vital powers, tone in particular, possess a powerful influence upon the production of heat.

7th. Each organ is possessed of its peculiar degree of temperature, and it is from these that the general temperature results.

8th. There is often an immediate connection between the phenomena of respiration and circulation and those of the production of heat; at other times these connections do not exist.

If under these phenomena we place the theory of Lavoisier, Crawford, &c., I do not believe we can bring them to coincide, and conceive how caloric, formed in the capillary system of the lungs, can possibly, as they have conceived, be extended throughout the animal economy. On the contrary, by admitting this fluid to arise in the general capillary system, the supposition is easy. But let us first lay down this mode of conceiving the production of animal heat.

The blood receives from two principal sources the substances that repair the losses it has sustained; these are—1st. Digestion; 2nd. Respiration. The former pours the chyle into the blood, the latter mixes with this fluid different atmospheric principles. Sometimes the matter absorbed from the skin is also added to its different substances. The intermixture of the blood with the new substances it receives constitutes hematosis. Now, these new substances incessantly bring with them in this fluid a supply of caloric; for, as all bodies are impregnated with this fluid, there can scarcely exist an addition of substance without an addition of this principle. In hematosis, then, the caloric is combined with the blood, but is not disengaged; it forms a part of the fluid; it is one of its elements.

Thus loaded with combined caloric, the blood reaches the capillary system; it is there distributed throughout, where it becomes changed. It is, in fact, in this system that it is converted into the nutritive substance—into those of the secretions, the exhalations, &c. Every function in which the nature of this fluid is changed, in which peculiar principles are separated from it to constitute particular substances especially intended for such or such purposes, must necessarily deprive it of part of its caloric. I cannot pretend to say precisely how this is performed—whether it proceeds from the internal changes which the blood undergoes to supply nutrition, or from those intended to provide for secretion or exhalation. The following, however, is the general principle: it may be divided into three parts:—

1st. Admission of caloric into the blood, with all the substances intended to repair its losses.

2nd. Circulation in a combined state of the caloric newly received.

3rd. Separation of this combined fluid from the blood to form free caloric, by the various alterations it undergoes in the general capillary system, on preparing the materials for the different functions.

The formation of caloric, then, is a phenomenon perfectly similar to those which take place in the general capillary system. In fact, in nutrition there are also—

1st. Combination of new foreign substances with the blood.

2nd. Circulation in the large vessels of these combined substances.

3rd. Separation of the nutritive substance to permeate the organs. In the same way the elements of the secreted fluids are combined, circulate in this state, then separate from the blood to be expelled: finally, in the same manner every exhaled fluid is combined, circulated with, and afterwards separated from the blood.

From this it is evident, that, 1st. The admission of foreign substances in the blood, through respiration, digestion, or even cutaneous absorption; 2nd. The combination of these substances with the blood in hematosis; 3rd. Their circulation in the arterial system are three general phenomena, common to secretions, exhalations, nutrition, and the formation of heat.

Caloric then reaches the capillary system combined with the matter for the secretions, that for exhalation, and that intended for nutrition. The blood is the common fluid resulting from all these combinations. Each part is separated in the general capillary system; the caloric to extend throughout the body, and be afterwards emitted; the fluids for secretions to flow from the glands; those for exhalations to transude through their respective surfaces, and the nutritive substance to remain in the organs.

It appears to me that an explanation, which represents nature as constantly pursuing a regular course in all her works, drawing all her results from the same principles, affords at once a degree of probability very different from that which represents her insulating, as it were, this phenomenon from all others, by the manner in which it is produced.

It is of little consequence by whatever mode caloric is introduced into the system. Vegetables that have no lungs, but air tubes and absorbents; fishes that are [possessed of gills; all enjoy an independent temperature. To produce heat, it is sufficient that foreign substances be incessantly assimilated with the humours of organized forms, and, that subsequent to this, these humours, whether they are blood, as in animals possessed of red blood, either warm or cold, or of a different nature, as in those which circulate white fluids, and in plants, it is sufficient to say, that they undergo in the capillary system different changes.

Respiration combines more caloric with the blood, consequently, this principle is formed in greater quantity in animals that breathe by lungs than in others; and even in the first class, the larger the lungs the greater the heat, as is proved by comparing birds and quadrupeds, the cetaceous tribe in fishes, &c. These variations, however, relate only to the degree of temperature; hence, there are animals possessed of cold blood, and those in which it is warm. The general phenomena in the production of heat, both in animals provided with lungs, and in those in which this mode of respiration is wanting, and in plants, will ever remain the same.

From these principles the greatest part of the phenomena relating to animal heat are easily conceived.

The production of heat is, in all instances, subordinate to the state of the vital powers. Accordingly, as the tone is languid or exalted in the part, this part possesses more or less heat. This dependance of heat on the state of the powers in a part, is a fact ascertained in diseases as well as in all the phenomena of health: it is as real in regard to heat as it is correct in respect to the exhalations and secretions.

The greater the afflux of blood in a part affected with inflammation, the more considerable the production of caloric; the increase of that fluid in the womb, in the nose, and menstruation, the active hemorrhages of the fossæ nasales, the burning sensation in the chest, and the acute hemorrhages of the lungs, &c., all proceed from the same cause, namely, from an increase of the vital powers in the part. In general, when the tone is much increased, heat increases also. This explains why, in almost every case of perspiration, hemorrhage, and even active secretions, caloric is produced in greater abundance, whilst there is no superabundance of this fluid in those sweats, hemorrhages, and secretions, denominated passive, whatever may be the quantity of fluid separated by their means from the blood.

Each system is possessed of its peculiar mode of heat; less caloric is certainly produced in the hair, the nails, the epidermis, than in any other system: the white organs, as the tendons, aponeurosis, the ligaments, cartilages, &c. probably furnish less than the muscles. Let us examine the feet of birds, in which these white parts only exist: they are much colder than the remainder of the body.

The different degrees of heat in each system, situate internally, has not yet been analyzed. I am convinced that, if this were done with precision, separating such as admit of it, so as to let them communicate through the vessels, it would be found that each emits a different quantity of caloric, that consequently, in the general temperature, there are as many partial degrees of heat as there are organized systems.

I am convinced that ligaments, cartilages, &c. approach, in this respect, the organs of cold blooded animals; and that if the human being were composed of organs similar to these, his temperature would be very much inferior to what it is naturally. The systems in which more caloric is formed, supply with this fluid those which possess less. If the hair were situate within the body, it would be as warm as the surrounding parts, although possessed of an independent temperature; it always remains inferior to that of the body, because it is separated from it. Each system then has its peculiar mode of heat, in the same manner as each gland has its peculiar mode of secretion; each exhaling surface, its peculiar mode of exhalation, each tissue its peculiar mode of nutrition, and all this directly proceeds from the modifications of the vital powers in each part.

It is in consequence of this mode of heat, peculiar to each system, that in inflammation each conveys, as it were, a different sensation. Let us compare the sharp smarting heat of erysipelas to that sensation in the lungs, the peculiar obtuse pains, preceding organic affections, with the acute heat of the different inflammations, and if in different fevers we apply the hand to the skin, we shall find that each is almost characterized by a peculiar heat. These varieties in the nature of heat are only met with in animal forms; minerals afford only varieties of its intensity.

From the principles above stated, we may form an idea not only of the local alterations of heat, but also of the general disturbance that takes place in its production, from a number of diseases, whether it be that this production has increased or diminished, or again, that it is irregular, as in peculiar fevers; for instance, in pulmonary consumption, when the palm of the hand and the face are warmer than on other occasions, &c. Who is not aware that the extreme parts are frequently chilled, whilst the patient feels an intense heat inwardly? The different changes in the powers of the capillary system are sufficient to produce different modifications of heat. The variations of heat, in fact, are as frequent in diseases as those of secretion and exhalation, and similar to the latter, they invariably display a previous discordance in the vital powers. Let chemists apply their theories to these morbid changes of heat, and they must necessarily find an insurmountable obstacle, whilst, in regarding this phenomenon as I have represented, these changes are the necessary consequence of the state of the vital powers at the moment.

After running swiftly, or when the blood is excessively agitated during fever, more caloric is formed than at any other time. Does this prove that the general circulation is intended for its production, and that it takes place in the large vessels? No, no more than in the same case, the abundance of perspiration proves it is expelled by the heart. The capillary and the exhaling systems being strongly excited by the impetus of the red blood suddenly increased, their action is increased; and from these two effects result, 1st. More heat is disengaged; 2dly. The exhalation is increased.

If heat be increased when respiration is more rapid, it appears to proceed from the circumstance of this being hardly ever accelerated without the other being equally so. This assertion is so perfectly correct, that if inspiration and respiration be continued in more rapid succession for some time, the temperature is not thereby increased; besides, why should heat be actually increased by the rapidity of respiration? Undoubtedly because a greater quantity of air being admitted in a given time, the lungs would absorb more oxygen, and consequently, according to the opinion of chemists, more caloric would be produced; but if more or less of this principle be presented to the blood, more is not absorbed. In natural respiration, the air contains a much greater quantity of this fluid than is received by the blood; when breathed in a pure state by an animal, the blood does not become redder, because no more than the usual quantity is absorbed. In the same manner, if the gastric organs be loaded with four times the quantity of nutritive chyle, the lacteals reject the superabundance; the evacuations only are more copious, or the superfluity is discharged by vomiting.

The state of inspiration then does not interfere with the habitual heat of the body; it contributes to it no further, than by introducing continually into the system a greater or less quantity of combined caloric. It is on this account that animals possessing respiration, are also possessed of more habitual heat.

How can it be accounted for that animals, breathing very cold air, and living upon food, containing scarcely any caloric in the northern latitudes, feel as warm as when under the torrid zone? because it is not the free caloric contained in the parts, but the combined, which being admitted into the blood with the heterogeneous substances, supplies with materials that which is produced in the general capillary system. Now, the combined caloric is perfectly independent of temperature; an equal quantity of sparks will flash from the flint in the coldest as well as the warmest climate.

The whole quantity of caloric combined with the red blood is not disengaged whilst this fluid passes through the general capillary system; more remains in combination with the dark blood. Hence, in the first degree of asphyxia, and previous to death, although from the interruption of respiration, the whole mass of blood transmitted by the arteries to the capillary system being black, heat is still continued for some time, even when the contact of the dark blood has suspended all the essential functions, such as those of the brain, of the muscles, of the heart, of the lungs, &c. It appears, that even then, the dark blood still experiences in the capillary system a kind of oscillation, by which some caloric is emitted. Thus it is, that subjects suffocated by charcoal, that have been hung, or have died from apoplexy, and animals killed by the air-pump, &c. still retain their heat for some time after death, as every medical man must have observed.

This phenomenon, besides, is not peculiar to the case we are now considering. On opening bodies, in the Hôtel Dieu, I have observed, that the time when animal heat subsides varies astonishingly; that the corpse remains warm for a longer or shorter space of time, particularly amongst those who have died suddenly from acute affections, the delirium of particular fevers for instance, from a fall, &c. &c. Such as have died in consequence of chronic disease lose their heat almost immediately. The difference compared with the former, is often three, four, or even six hours. This phenomenon proceeds from the following cause, that whenever death is sudden, it suspends the important functions only; the tonic action of the parts is still continued for a longer or shorter time. Now this action still separates some caloric from the blood that stagnates in the general capillary system. Thus, subsequent to violent death, absorption is still continued for a limited time after the subject has expired: the muscles still tremble, and the glands perhaps borrow for a few hours longer, from the blood stagnant in their capillary system, the materials intended for their secretions.

This difference of heat in the dead body can only proceed from the cause I have ascribed; for whenever the production of caloric has ceased in the body, that which remains sinks to a level with atmospheric air, and follows the general laws respecting it. Now these laws being uniform, their effects must be the same in every instance. Such are phenomena, which, in common with those above stated, are evidently in opposition with every theory that does not admit of caloric being produced in the general capillary system.

Sympathies, as we know, have the greatest influence upon the degree of heat. Accordingly as such or such a part is affected, more or less of this fluid is produced; in some syncopy is frequently attended with an icy coldness. Ulceration in the lungs produces a burning sensation in the palm of the hand. In other affections, the head seems to be the active focus of heat. In fever, the patient often feels chilled in one part, and heated in another. How can this be accounted for? the following lines will explain it: The affected organ acts sympathetically on the tonic powers of the part, these by increasing cause a greater production of caloric than in the natural state: it is similar to what occurs in the sympathetic secretions and exhalations, whether the vital powers be increased, either by a direct stimulus, or by the sympathetic influence they receive in a part, it is exactly the same in relation to the effect.

This sympathetic increase of heat should be distinguished from such as are produced by an aberration of perception, as when we imagine that we feel excessive heat or cold in a part, and even experience a sensation perfectly similar to the natural one, although the part to which this sensation is referred continues in its natural state, and has produced neither more nor less caloric. It is, in short, the same thing as when we figure to ourselves that we experience pain in the amputated limb. This is an aberration of perception, a real sympathy of animal sensibility, whilst the former is a sympathy of organic insensible contractility, or tone. It is this last property that is affected: the production of caloric is only consecutive, it is continued as usual, as well as perception that indicates its existence. A strange hand applied to the part will feel nothing new in the first case, which I shall explain more fully in the following systems: in this, it experiences a warmer sensation. In the same manner, if the sympathetic influence be calculated to reduce the tonic powers, less heat is disengaged in the part, which is sensible to the individual himself, or to any other that applies the hand to the part. Diseases incessantly display these phenomena relative to heat, and which cannot be explained by any other theory.

In this theory, however, as well as in any other, there exists a phenomenon not perfectly understood; namely, the faculty that animals are endowed with, of resisting external heat. Every inert body has a temperature similar to that wherein it is placed. Every organized body, on the contrary, repels caloric that in higher temperatures is disposed to penetrate it. This depends upon the propagation of heat, with which we are not yet perfectly acquainted.

It may be asked, why, in the natural state, a certain quantity of caloric only is disengaged to produce an habitual temperature of so many degrees by the thermometer? I shall answer, by the very same cause that produces nearly a special number of pulsations in each second in the natural state, that makes the usual respiration to consist in a certain number of alternate elevations and depressions of the ribs, &c. &c.

There are phenomena invariably united to the immutable order originally established, and which it is impossible to explain, only it appears that this immutable order depends upon the primitive type impressed upon the vital powers, a type which, when neither increased nor diminished, will continue to produce phenomena nearly uniform; but as numberless causes may occasion them to vary, so will pulsation, respiration, caloric, &c., vary. I shall, however, observe, in respect to the latter, that these variations are more narrowly circumscribed than those of several other functions. If, for instance, we compare the usual quantity of fluids exhaled and secreted in the natural state with the increase it admits of in peculiar cases, the general state of the pulse with its exacerbation in numerous fevers, &c., we shall find that between the natural state and the contrary one there is frequently an astonishing difference.

The temperature, on the contrary, never exceeds that of the natural state of the body more than a few degrees. In cases even where on touching the parts we suppose a material difference, the thermometer shows that it is in fact but trifling.

In concluding this chapter, I shall observe, that I have not attempted to decide in what manner caloric is produced in the capillary system, in what proportion it is evaporated, nor how far it is connected with the circulation of the dark and the red blood, &c., nothing of this can be submitted to experiment. Let us be satisfied then, in our theories, with pointing out the general principles, and particularly with tracing analogies between functions, the nature of which is known, and those we are endeavouring to account for, by presenting a general outline; but let us never hazard a strict explanation. It has been tried of late, to determine precisely what quantity of oxygen was absorbed, what was required to produce the water of respiration, the quantity of carbonic acid gas produced, the caloric exhaled, &c. This accuracy would prove advantageous if it could be attained; but not a single phenomenon in the living economy can admit of it in the explanations they give rise to: chemists, and those in pursuit of natural philosophy, accustomed to study the phenomena over which physical powers preside, have transferred their theoretical calculations to the laws of vitality; but it is no longer the same thing. The mode of theorizing with regard to organized bodies must be quite different from that of theories applied to the sciences of natural philosophy; these require that each phenomenon should be strictly explained; that, in respect to hydraulics, for instance, the motion of every particle should be calculated; that, in regard to chemistry, the precise sum of each element combined in the transformations of substances should be ascertained.

Every physiological explanation on the contrary should present nothing more than outlines and approximations; it should be vague, if I may be allowed the term. All calculations, all study of proportions between the fluids, all dogmatical language must be laid aside, because we are yet so little acquainted with the vital laws, and these are liable to so many variations, that what may be correct at one moment may not be so at another, and the essence of the phenomenon continually elude observation: the general results alone, and the comparison of these results, should command our attention.

ARTICLE II.

Capillary System of the Lungs.

By this I mean, the whole of that fine and delicate plexus, which, affording a termination to the dark blood, gives rise to the red, that terminates consequently the pulmonary artery, and from which the veins of the same appellation arise. The capillary vessels, intermediate to the bronchial arteries and veins, are quite distinct from these; they have no communication with them, and evidently belong to the general capillary system.

SECTION I.

Connections between the two Capillary Systems, the Pulmonary and the General one.

By comparing the preceding system with the present, it is difficult to conceive how they can exactly correspond; how the pulmonary can transmit not only all that is conveyed through the general system, but likewise all the lymph that is returned from the serous surfaces and cellular cavities, all the chyle admitted on digestion, &c.

It appears impossible, at first, that these capillary vessels should maintain a constant and regular equilibrium with those of the whole body in the balance of circulation. After some reflection, however, respecting the phenomena of this function, the discordance will be found to exist in appearance only.

Although the general capillary system is every where extended, the part through which the blood is circulated is much more confined than would appear at first sight. In the first place, a great number of vessels in this system contain fluids differing from the blood, and moved in a variety of directions. Besides, where they are especially filled with this fluid, as in the muscles, mucous surfaces, &c. a considerable part of it, particularly of its colouring substance, is in a combined state, and does not circulate. If in an animal a muscle be divided transversely, inspection will evidently demonstrate this phenomenon, which, added to the preceding, instantly reduces more than half the mass of blood which at first appeared to circulate in the general capillary system.

It is evident, however, there always remains more in this system than what is contained in that of the lungs, and to be convinced of this it is only requisite to divide the lungs of a living animal. Hence it is clear, that if the heart presided over the motion of the blood in the general system, that, if, consequently, all that it contained were propelled into the veins at each pulsation, the capillary vessels of the lungs would not be capable of transmitting it; but an assigned quantity, and proportioned to what the lungs can receive, only, is always conveyed. The same thing occurs as when the veins are considerably dilated, they contain more blood, and yet a greater proportion is not returned to the heart, because, as I have previously stated, the acceleration is in a reverse ratio to the capacity.

Various causes at every moment determine the blood to the general capillary system, from the natural impulse by which it is conveyed from the arteries to the veins: these causes are especially the exhalations, secretions, and nutrition. The capillary system is, as I have previously stated, a common reservoir, from which the blood is conveyed in various, and even quite opposite directions, on one part towards the veins, on another towards the exhaling organs, on a third towards the excretory tubes, and finally, on a fourth into the nutritive organs. In the capillary system of the lungs, on the contrary, there is but one single impulse, a sole direction; it is that which conveys the blood from the artery to the pulmonary veins: in this motion nothing diverts the fluid; for, on being changed in colour from black into red, the blood does not contribute to any function; there are no vessels towards which its motion is directed, except the pulmonary veins. This then is an important difference in the blood of the capillary vessels of the lungs, and that of all the other parts; namely, that the first is moved in one direction only; that the whole mass of that fluid which enters the lungs is instantly conveyed in that direction, whilst the other follows three or four different directions. Hence, this must necessarily oscillate and vary in its motions, if I may be allowed the expression, through the exhalants, the excretories, the nutritive organs and the veins; whilst the former having only one single issue, proceeds to it constantly and with uniformity. Let us, then, cease to wonder at the disproportions in capacity existing between the capillary systems.

The circumstance of being more or less distant from the heart, is another real cause that contributes to maintain harmony between the two systems. In fact, we have found that each contraction of the left ventricle communicates a sudden motion to the whole vascular mass contained in the arteries, and that at the very moment this mass is increased on one side it is reduced on the other by the portion of fluid conveyed into the capillaries of the whole body. Thus then, the arterial motion is not progressive, but abrupt and instantaneous; thus, at the very same moment the column of the blood in the aorta is increased towards the heart, and diminished in its most remote ramifications, and the fluid expelled from the heart at each contraction only reaches the capillary vessels, after a repeated number of contractions, since the part expelled from the heart can only reach these organs after that which has preceded has reached its place of destination. The same phenomenon exists in respect to the dark blood in the pulmonary artery. The greater then the distance, the more time the blood requires to reach the capillary vessels, and consequently to flow through them; and the blood proceeding from the right ventricle must take much less time to reach the left auricle, than that supplied by the left ventricle will require to be returned to the right auricle; then, although in what is commonly called the small circulation, the rapidity is not greater, the distances over-run being less, the time required is also less; then again, the surplus of fluid contained in the divisions of the aorta, in the general capillary system, and in the general veins, over the quantity contained in the pulmonary arteries, veins, and capillary system of the lungs, is counterbalanced by the length of time the latter requires to complete its course, which is short, when compared with that required for the former.

From this we find, why, in these classes of the animal creation, in which the lungs in respect to circulation are opposed to the whole body, nature has constantly placed that organ next to the heart; if the one were placed in the head, and the other in the lower region of the pelvis, the harmony would be necessarily destroyed.

SECTION II.

Remarks on Circulation in the Capillary Vessels of the Lungs.

Since the blood from all the parts constantly traverses the lungs, it is evident that any injury to the functions of this organ must be felt throughout the body. This is established by what occurs in asphyxia. It is in this respect they are directly connected with life, and that physicians in former times had enumerated their functions among those they termed vital.

It is also conceived why pulmonary inflammations possess such a peculiar character, why they are distinguished from others by innumerable phenomena; not one of the internal organs is more frequently affected with inflammation; if this were not sufficiently ascertained by experiment at the patient's bedside, dissection would establish its truth. In fact, signs of former inflammation are very frequently found in the lungs, particularly adhesions of the pleura, a phenomenon so common, that I do not hesitate to say, this membrane is more frequently found thus affected than in its natural state. This is an essential difference between this membrane and all others similar, a difference it is indebted to the organ it envelopes. Various causes contribute to this remarkable propensity to pulmonary inflammations; 1st. Amongst the internal organs the lungs are the most exposed to direct irritations, either by air that habitually penetrates them, and may cause irritation, or by heterogeneous substances of which it is the vehicle, or still more from the alternate changes of heat and cold; 2dly. This organ is connected with the other systems, the cutaneous for instance, by numerous sympathies, so far even, that perhaps in regard to inflammation, the lungs alone are more influenced by a suppression of perspiration than all the other organs together, which undoubtedly depends upon this organ answering alone to all the other capillary vessels.

When the lungs are affected with inflammation, is it the red blood of the bronchial artery, or the dark blood of the pulmonary artery, that flows to the irritated part? I rather think this question could not be easily resolved by experiment, but the inspection of dead bodies seems to prove that the latter takes a very active part: in fact, this organ is frequently filled with such rapidity, that it is not easy to attribute this to the former; sometimes, which however is not always the case, we might, as it were, follow the progress of this surcharge by the percussion, which is infinitely less sonorous in the morning than in the evening. Two months ago a patient died in the hospital, the distinction was very striking in this subject from hour to hour. In the greatest number of cases the progress is certainly less rapid, it cannot be called in question; but the dark blood had contributed to produce this state of the lungs.

No organ whatever in the animal economy acquires by inflammation greater size and weight in so short a time, of which all who are in the habit of opening the dead body are convinced. When divided in those who have died from peripneumony, we are induced to say it is the solids that have increased: in respect to weight, it frequently resembles the liver, but if submitted to maceration, the whole will become fluid.

Now if we examine comparatively the skin, the stomach, the liver, the kidneys, &c., after acute inflammation, followed by death, they exhibit nothing to be compared to this enormous increase of fluid with which the substance of the lungs is loaded; from inflammation, not only the spaces in the cells are filled, but the organ is also considerably dilated. I have had frequent opportunities of dissecting the bodies of those who have died of peripneumony, in which I found one of the lobes perfectly sound; but the disproportion in weight between the sound lobe and the other was incomparably greater than that between the kidney affected by inflammation, and in a healthy state.

This phenomenon evidently proceeds from the lungs receiving alone as much blood as the whole body, and more blood being therefore accumulated in a given time when its course is deranged by the process of inflammation. To speak more correctly, however, it is not with blood that the lungs in these cases are found to be gorged: when expelled by pressure, the fluid appears white; it seems to be a kind of pus. Much has been said of imposthumes subsequent to this disease; but these cases are extremely rare: the lungs, in almost every instance, are infiltrated; the fluid does not collect in a sac.

Does the blood, in pulmonary inflammations, penetrate vessels that were not originally intended to circulate this fluid, as may be seen evidently on the serous surfaces, on the tunica conjunctiva when inflamed, &c.? I believe not; because no other vessels have been discovered in the lungs besides those intended for the blood. It seems evidently to be the blood, or the other fluids, that are deposited in the pulmonary tissue by the exhalants. It cannot be doubted that in peculiar phlegmons the blood penetrates, as I shall prove, into the interstices of the cellular tissue, and it appears to be the case here. By tearing or cutting the lungs, when in a state of inflammation, it is evident that the whole tissue is gorged and infiltrated, whilst on examining a serous surface, similarly affected, the blood is found contained in the capillary tubes.

It is indeed a great error to consider that inflammation is the same in every part presenting both the fluids, and their vessels, as constantly in the same state. Boerhaave, for instance, thought inflammation could not exist without the error loci, as it was termed. There are, according to the state of the parts, their structure, and vital powers, innumerable modifications in the new anatomical order which this affection imparts to the organs.

What constitutes the essence of inflammation is,

1st. Irritation of the inflamed part.

2dly. The changes in the vital powers from this irritation.

3dly. The consequent stagnation of humours round the irritated parts.

But in whatever manner these humours are fixed, whether they have ceased to circulate in the capillary system, or that their motion has been checked by the exhalants; or again, that they have been extravasated in the adjacent tubes, &c., they are as many different effects depending upon the different organization of the parts; but the principle is always the same, it is invariably the same disease. If we could analyse accurately the state of every system in a state of inflammation, we might perhaps find that in each it is different.

Besides the diversity of symptoms this disease unfolds—a diversity I have already stated—evidently proves that the state of the solids and fluids is not the same.

How is it, then, that the whole vascular mass in peculiar cases of phthisis, in which the lungs are reduced to half their usual size, flows through this organ? I shall observe in this respect, that the large vessels contain less blood in proportion as the lungs are more ulcerated. The reduced state of this fluid, in respect to quantity, is very remarkable in many organic affections; but more particularly, as Portal has observed, in this. If, in phthisis, the same quantity of blood were circulated as before, the circulation could not be continued, or there would be a constant reflux towards the right auricle. We are aware that in this complaint the pulse is weak, feeble although frequent, particularly towards night? Compare this pulsation with that in inflammatory fever, in which plethora is evident, and they will prove to be quite reversed.

I shall even state a general observation in this respect, which is, that whenever the powers are declining in our organs, vitality becomes languid; there is almost constantly a proportionate diminution of blood, so that allowing this fluid to be the resisting power opposed to that of the vessels, the proportion between this power and this resistance always remains the same—a due balance must exist. If the blood were transfused in consumptive cases, it would produce death, because the powers of the solids would not correspond with the consequent increase of action.

Circulation in the capillary vessels of the lungs, is like that in other tubes; they are influenced by the tonic powers of the part, and not by the impulse of the heart. This impulse terminates with the ramifications of the pulmonary artery. In cases then of inflammation in the lungs, the blood is not mechanically obstructed in this organ; bleeding is not intended to reduce the vis a tergo. Forty ounces of blood might be drawn from the patient without in general the lungs being lessened. They would be less excited on account of the diminished afflux of this fluid; but that stagnated in the capillary system will still remain. As long as irritation subsists, that irritation will be, as it were, a loadstone that attracts the blood, and completely diverts it from its intended course: previously, this course was from the artery to the veins; now, it will be exclusively to the irritated part. Bleeding, then, acts, 1st. By reducing the quantity of blood that reaches the lungs, and consequently, by unburthening the diseased organ. 2dly. By lessening irritation in the solid; an irritation that attracts the blood, and fixes it in the part.

The habitual excitement impressed by the air on the capillary system of the lungs, promotes its circulation; but the blood might circulate through this system independent of this excitement, as my experiments, already stated, have proved.

SECTION III.

Alteration of the Blood in the Capillary Vessels of the Lungs.

The very reverse of what exists in respect to the general capillary vessels takes place in these. We in reality know very little respecting the causes of this phenomenon, but it is my opinion that new experiments should be made before any explanation be attempted. This is of so much more importance, that if we were perfectly conscious how the dark blood is converted into red, we should soon find the reason why the red is also changed in colour.

In my book on life and death, I have presented the phenomena relating to this process; it would be superfluous to repeat them here. Numerous particulars respecting the circulation in both capillary systems, which I shall also avoid repeating, will be found in the same work.

SECTION IV.

Remarks on the State of the Lungs in the Dead Body.

I SHALL confine myself here solely to a remark, already stated in the book alluded to, namely, the very frequent obstructions to which the lungs are liable at the moment of death. This organ alone receiving the blood of the whole body, from the moment the powers sink this fluid stagnates and is accumulated; so that, according to the state of the powers at the time of death, let the disease be what it may, it will vary in weight, and be more or less filled with fluids, so that it will scarcely ever be seen twice in the same state. Such obstructions are constantly found when death has been attended with agony. Thus, on comparing the lungs in the dissecting rooms with those of animals killed in the slaughter houses, they are perfectly distinct; in the former, the organization is generally obscured by the fluids that overload them. This organization can only be properly seen in subjects that have died subsequent to hemorrhage or in syncopy; in the greatest part of the others it is impossible to distinguish any thing. This undoubtedly explains why we are still so imperfectly acquainted with the intimate structure of this important organ, as I shall endeavour to prove, by the description I have previously given, how we may at will accumulate more or less blood in the lungs of the animal, according to the method adopted for its destruction.

No other organ in the economy displays, at least in so striking a light, these excessive varieties of obstructions in the lungs at the instant of death, because, without doubt, there are none which like the lungs form a central point for circulation; I do not even, as I have said before, except the liver. In this respect, those who dissect and examine the state of the lungs, should be particularly careful in distinguishing properly obstruction proceeding from the disease, from that produced by impediments to circulation, at the last moments. I will suppose two cases of pulmonary disease, perfectly similar in their nature, their progress, and the subjects they affect; if one of these subjects die in syncopy, and in the other, on the contrary, death be attended with a long continued agony, and the rattling in the throat, the lungs in the latter will weigh considerably more than those of the former.

It is highly probable that, during life, the lungs are likewise obstructed in various degrees. We are conscious, that in the greatest part of the chronic diseases that affect this organ, whenever the patient takes rather too violent exercise, they will occasion a feeling of oppression, suffocation, &c., which are apparently only owing to the superabundance of blood which, being prevented from flowing through this organ with the same degree of rapidity as it is propelled, stagnates and obstructs the admission and expulsion of air; the diseases of the lungs, and of the heart only, are constantly attended with sensations of oppression and suffocation. In aneurism, and sometimes in cases of ossification, it is very striking in respect to the latter organ.

EXHALANT SYSTEM.

Exhalation and secretion are two similar functions in this respect, that both separate from the blood liquids distinct from this fluid, and pour them over various surfaces, where they are intended for different purposes. Their distinctions are as follows:

1st. In exhalation there is no organ intermediate to the arteries and exhaling vessels; they are only separated by a capillary plexus, whilst, on the contrary, an intermediate organ is always found between the excretory vessels and the arteries. This organ is the capillary system; from their minute tubes the former arise, and the latter terminate.

2dly. The organized mechanism that elaborates the secreted fluids, is then much more complicated than that which separates the exhaled substances. Thus the former, as the bile, urine, salive, &c. on one part differ essentially from the blood, and on the other, prove considerably compounded, whilst the latter, as the serum, &c. on one hand, bearing a striking similitude to certain parts of the blood, and on the other, as they contain but few elements, are but very indifferently compounded. This two-fold distinctive character in both species of these fluids, appear to me decidedly conclusive.

3dly. The exhaled fluids are poured out by an innumerable quantity of minute vessels separate from each other; the secreted fluids, on the contrary, are gathered in one or several principal tubes, that pour them over the surfaces to which they resort.

4thly. The greatest part of the former, after being exhaled, are returned into the circulation; the latter, on the contrary, seem essentially intended to be expelled inwardly.

5thly. Numerous parts receive the exhalations; they are deposited upon the serous, mucous, synovial, cutaneous surfaces, in the cellular tissue, and even in every organ that interferes with nutrition. The mucous and cutaneous surfaces, particularly the former, are the only organs over which the secretions are spread.

From all these considerations it results, that exhaled fluids, as the fat, serum, synovia, marrow, &c. differ essentially from those which are secreted, as the bile, urine, saliva, the mucous fluid, as that of the prostate gland, the semen, pancreatic humours, &c. This distinction appears to have been strongly felt by a number of authors; the greatest part, however, have adopted the word secretion, to express the separation of exhaled fluids from the mass of the blood. I certainly admit that there is a considerable analogy between exhalations and secretions. In both instances, as I have previously stated, the capillary system exists between the organs that import and those which carry out the fluids; but this system is certainly quite differently organized in a gland, and in a mucous surface, for instance, wherever there is exhalation, most undoubtedly the capillary system only exists; but the parts intended for secretion are of too much importance not to require something more; besides, on being guided by inspection only, and without pretending to enter into the intimate nature of the organ, it is evident, that wherever secretion is performed, a gland exists, and that this organ is wanting where exhalation only is carried on.

ARTICLE I.

General Distribution of the Exhalants.

SECTION I.

Origin, Course, and Termination.

Authors have formed very different opinions in respect to the exhalants. The decreasing tubes stated by Boerhaave, and the error loci, for which his imagination had created them, we are perfectly familiar with. Latterly, all white organs, as a continuation to arteries, have been rejected, and to explain how exhalation is effected, inorganic pores of the arterial parieties, through which the fluids are supposed to transude over the organs, are resorted to. The frequent observation of similar transudations in the dead body, such, for instance, as that of bile through the gall bladder, of marrow through the bony tissue, to which it imparts a yellowish colour, &c. is one essential basis on which this manner of viewing the exhaling system rests. But we have already frequently noticed, that these phenomena never take place during life, when the organic sensibility of the parts will not admit of them. Exhalation besides is evidently subjected to the influence of the vital powers, since it constantly varies in a part accordingly as these vital powers also vary; besides, if exhaled fluids transuded through inorganic parieties, it would be requisite, that not only the vascular parieties, but also those of the serous surfaces which receive this fluid, should be perforated with innumerable minute holes; but why is it then, that the fluids, for which they form reservoirs, do not transude into the cellular tissue? Let us then lay aside all kind of opinion unsupported by anatomical observation, and endeavour, according to this observation, to discover what exhalants are.

To form a correct idea of the organs, always concealed from us by their excessive tenuity in the natural state, is undoubtedly attended with great difficulty. By means, however, of experiments and strict reasoning, it appears to me that this end might be attained.

We have seen that the existence of a capillary system terminating the arteries, is indisputably proved by experiments with injections, by inflammations spontaneously produced, and by those formed at will in parts where exhalation takes place, as well as in others, in such a manner even, that a serous, a cutaneous surface, &c. where nothing appeared before, is in the first case instantaneously covered with an innumerable number of small vessels, and also in the second, after an interval of time more or less variable.

If the injection be not carried too far, it will be restricted to the capillary system, but if it succeed, it will shower from every quarter on the surface where exhalation occurs in the natural state. This effusion perfectly resembles that produced in the living subject by the tonic powers of the part; for, as I have before stated, if it transuded, infiltration would ensue in the adjoining tissues, whilst from the syringe that conveys the injection up to the exhaling vessels that pour the fluid, nothing except the arteries, the capillaries, and exhalants, are filled. Besides, whenever active hemorrhage takes place, the capillary tubes, from which the exhalants arise, evidently, as I have before stated, contain more fluid than usual.

From these considerations, and many others, that will be occasionally and successively brought forward in treating of this system, I am led to believe that the exhalants may be represented as arising from the capillary system, by means of which they are continued with the arteries that supply them with the materials for exhalation.

But to undertake to ascertain the extent of these vessels, their form, how they act in the track they overrun, is evidently an impossibility; here, indeed, imaginary descriptions would begin. Their orifices are not distinguished without the utmost difficulty. On the skin innumerable minute pores, evidently proving a communication from within, are in fact observed; but these pores not only transmit the exhalants, but also the absorbents, the hair, &c., as we shall find, in viewing the dermoïdal system. All duly considered, 1st. The existence of exhalants. 2dly. Their origin from the capillary system of the part where they are found. 3dly. Their termination on divers surfaces, are the only facts correctly ascertained.

The mode of origin undoubtedly varies, but we are ignorant of the way in which it is performed: the exhalants are connected with their respective capillary vessels, so much so, that it is even impossible to ascertain where the former begins, and where the latter ends. This explains why, in the course of this Work, when mentioning these imperceptible tubes, I have frequently supposed them as proceeding immediately from the arteries, and forming, by their intricate texture, the capillary net; it is sufficient if I have made myself understood.

SECTION II.

Division of the Exhalants.

There are three classes of exhaling vessels, distinguished by the fluids or substances they emit.

The first includes those which reject fluids that are not intended to be returned into the body. Such are, 1st. The cutaneous exhalants from which perspiration flows. 2dly. The mucous exhalants that form a part of the pulmonary perspiration, the greatest part being supplied, as I shall state, by the dissolution of the fluids of mucous respiration ; that pour out also the gastric, intestinal juices, &c.

In the second class are contained the exhaling vessels that reject the fluids which remain for some time on particular surfaces, or in cells, and which, subsequently claimed by absorption, are, by means of the lymphatics, returned to the course of circulation. To this I refer, 1st. The serous exhalants, which leave on their respective surfaces the serum that lubricates the membranes, and facilitates the motions of such organs as they cover. 2dly. The cellular exhalants that deposit in the cells the serum and the fat. 3dly. The medullary exhalants, that convey in the interior of the bone the medullary juices. 4thly. The synovial vessels that spread synovia both over the articulations, and in the tendinous junctures.

The third class comprehends the exhalants that convey to every organ the nutritive substance intended to repair losses, and which is subsequently taken up by absorption, to leave room for a new supply.

The division just stated, I have adopted in my lectures, to explain the different exhalations, the last of which evidently leads me to speak of nutrition; a function which is the general end of the greatest part of those constituting organic life. The different exhalations, and the assemblage of the organs commissioned to perform this function, are comprised in the following table:—

EXHALANTS.	1st. External opening upon	1st. The Dermoïdal. 2dly. The mucous systems.	
	2dly. Internal opening upon	1st. The serous system. 2dly. The cellular system in which they pour.	1st. Serum. 2dly. Fat.
		3dly. The medullary system.	1st. Of the short bones, of those which are flat, and of the ends of the long bones. 2dly. Of the middle of the long bones.
		4thly. The synovial system.	1st. Of the articulations. 2dly. Of the tendons.
	3dly. Nutritive.	Each organized tissue is provided with its peculiar exhalants.	

Such is a correct sketch of all the fluids that are separated from the blood, without the intervention of glands, and by exhalation only. The two first classes are provided with vessels that may, from experiments, observation, and even inspection, be strictly admitted. In regard to the nutritive exhalants, it cannot be doubted that the organs are incessantly supplied with fresh substances to repair the waste, and that these substances must necessarily require vessels to convey them. These vessels can certainly receive what they deposit from the capillary system only from which they proceed. If by injections or other means they cannot be accurately demonstrated, it appears to me that this argument would be sufficient for that purpose.

Physiologists have not hitherto arranged the different exhalations within the same class. Each was individually exposed on treating of the system in which it takes place. I have also produced such reflections respecting each in my exposure of the different tissues as the general anatomical order required; but in books, or in physiological lectures, it is evident that these, as well as absorption, should be represented in the same light.

SECTION III.

Difference of Exhalations.

Although we are unacquainted with the structure of the exhalants, yet it cannot be doubted that this structure must vary considerably in the different systems. These tubes being, as it were, elements in the organs they contribute to form, they must necessarily partake of the distinctive characters peculiar to each.

To those distinctions must undoubtedly be referred those met with in injections, if rather fluid, they flow from the mucous, serous, even from the cellular exhalants; but in those intended to transmit synovia, they pass with much greater difficulty. It is the same in the capillary system; whilst in this system injections pass with the greatest facility over the serous surfaces, that may be rendered livid; the synovial surfaces are not quite so readily permeated.

ARTICLE II.

Properties, Functions, Developement of the Exhalant System.

SECTION I.

Properties.

The vessels of the exhalant system are too minute to admit of analyzing the powers of the tissue. Do they become larger on being penetrated with the red particles? I really do not know. Haller, who admitted the existence of exhalants, had thought the white fluids only were admitted through their tubes, because their diameter was not in proportion with the red particles. This opinion also prevailed in the Boerhaavian school.

Who has ever attempted to ascertain the respective diameters of the vessels with the particles of the fluids? We may remark, that all these expressions, thin fluids, gross fluids, &c. still made use of by many physicians, have been introduced into medical practice by this theory, and have been continued, although the theory itself has been acknowledged false. I have frequently said, and I shall again repeat, the only cause that prevents the red particles from being admitted into the vessels intended to contain the white fluids, is the want of connection between the nature of the fluid and the sensibility of the organ.

The properties of animal life have evidently no connection with the exhalants. Amongst those of organic life, they possess the greatest degree of organic sensibility, and the correspondent insensible contractility. On these powers all their functions revolve.

Characters of the Vital Powers.

Although organic sensibility is possessed by all the exhalants, yet it varies remarkably in each system; that of the mucous system is not the same as that of the serous. In general, these vessels being, as it were, component parts of the tissue of each system, they absolutely partake of the organic properties of that system, or rather, the latter are identified with the former. Thus it happens, 1st. Why each separates the fluid it is peculiarly connected with; why, consequently, when from copious drinking a great quantity of water has been admitted into the circulation, it is the cutaneous exhalants, and never the serous, that appropriate the fluid to themselves, and subsequently separate it from the blood. After running swiftly, when the circulating mass is violently agitated by the power of the heart, the cutaneous vessels, more especially excited than the serous, the synovials, &c. separate more perspiration, &c.: 2dly. Why the serous exhalants do not convey fat, the medullary serum, &c. although the vascular mass that enters the capillary tubes, with which they are continued, is every where the same: 3dly. Why, whenever the exhalants pour out different fluids, or whenever their natural fluids are adulterated, these essentially differ from each other; why, again, for instance, subsequent to inflammation on the serous surfaces only, a milky serum is to be found; why nothing similar to pus flows from the medullary membrane, when in a state of inflammation; why the fluids resulting from inflammation of the synovial membranes, are very distinct from those produced by the serous surfaces, &c.: 4thly. Why peculiar exhalants have more tendency than others to receive the blood, and to transmit it to their respective surfaces, an instance of which is afforded those of the mucous membranes, which are so disposed to suffer this fluid to transude, that innumerable circumstances will produce hemorrhage in this membrane: 5thly. Why, even amongst the mucous exhalants, some more readily than others admit of a passage for the blood, &c. &c.

All these phenomena evidently proceed from the peculiar modifications that distinguish organic sensibility, and the corresponding contractility in each species of exhalants.

SECTION II.

Natural Exhalations.

All I have just stated, most clearly leads to an explanation how exhalation is performed: one principle only has hitherto been advanced for this purpose. The same will still be made use of to explain the secretions, absorptions, &c. There is, between the elements that form each exhaled fluid, and the organic sensibility of each species of exhalant, such a connection, that those elements only can be admitted in the vessels that refuse and reject the others, as long as their mode of sensibility undergoes no change. The general capillary system seems to be, as I have said before, the reservoir in which the blood is elaborated; it is there converted from red into black; its different elements are separated, combined anew, and in the changes they undergo their caloric is suffered to escape. It is subsequent to these alterations, these different transformations, that each exhalant claims and selects, as it were, the parts with which its sensibility is connected, and rejects the rest. From hence it follows, that whenever the organic sensibility of a system in which exhalation takes place is altered, the exhaled fluid must also vary—an effect that is constant. There is never any derangement in the process of exhalation, without a preceding one in the sensibility of the vessels. Let us, for instance, take the changes of transpiration, and we shall find that cold, heat, dryness, humidity, friction, &c., always exert an influence upon the cutaneous sensibility, and that the derangements of exhalation are merely consecutive.

The organic sensibility in the exhalants, as well as that in every other part, may be variously affected.

1st. By a direct stimulant, such as when cold causes the skin to contract, or when an excessive cold beverage acts upon the stomach, &c.

2dly. Through sympathies, as when the acute affection of the fibrous and muscular organs produces perspiration in a rheumatic complaint.

3dly. The vital powers in a part are often disturbed without our being able to account for it, which is so frequently ascertained in inflammation. I do not allude to the derangement that may be produced by the continuity of organs, &c. &c. From this it results, that whenever exhalation is preternaturally increased or diminished, the degree of sensibility in the exhalants is always modified in one of the three preceding ways.

Now, if we reflect upon the different kinds of exhalants, we shall find that, excepting the cutaneous and mucous, scarcely any are exposed to immediate excitement, because these alone are connected with external forms. Besides the two modes of alteration in sensibility, of which they partake with the rest, they have this also. Is it not then surprising that their exhaled fluids, especially those of the skin, afford such very frequent varieties, that the skin is found in a state constantly varying from the utmost degree of dryness to that of the most abundant perspiration? The sympathetic exhalations are excessively numerous. Here I shall produce no instances of them: they are frequently met with in viewing the sympathies of the dermoïdal, serous, and mucous systems, &c. Authors, however, have not sufficiently distinguished these exhalations, nor have they paid sufficient attention to sympathetic secretions.

The several exhalations never increase or fall all at the same time, excepting, however, in the erethema at the commencement of certain fevers, when they are entirely suppressed. In every other case, whenever one fluid is abundantly produced, the others are diminished: thus dryness of the skin coincides with dropsies. It has been remarked that perspiration is very abundant in the early stages of pulmonary consumptions; but that towards the termination of the disease, when leucophlegmacy has made considerable progress, the perspirations subside.

I have also separated into two classes, the causes of increased exhalations.

1st. Some denote an increase of vitality.

2dly. Others an actual decline of the vital powers. Hence, the active and passive exhalations. How the very same phenomenon can proceed from two causes exactly opposed to each other, is not easily determined with precision; but such an innumerable multiplicity of phenomena contribute to form this distinction, as well in regard to secretion as to exhalation, that it must be admitted. It is very important to recollect this on perusing the next chapter.

SECTION III.

Preternatural Exhalations.

By this appellation I distinguish those in which the exhalants emit a fluid different from that they naturally produce: the first which offers is the blood.

Sanguineous Exhalation.

The blood frequently flows through the exhalants instead of their peculiar fluids. From this, hemorrhages, very different to those produced by laceration, proceed. I shall examine these hemorrhages in each of the exhalants.

Hemorrhages of the Excrementitious Exhalants.

The common expression frequently made use of, to perspire blood and water, &c., denotes that in some peculiar cases, not very common however, the cutaneous exhalants give admission to the blood. Haller has quoted several instances, respecting which I refer to his book. The first year I practised in Paris, I usually attended, together with Desault, a female afflicted with a cancer in the womb, and which, at peculiar stated periods, was subject to perspirations that stained the sheets nearly in the same manner as the periodical discharge would do the cloth worn to receive it. Previous to this disease, she had laboured under frequent hemorrhage, and since these perspirations commenced, it had continued to return, but at more distant intervals. I regret having neglected to state the particulars of this singular fact.

No exhalants in the economy pour out blood more frequently than the mucous: thus are these affections nearly characteristic of the mucous surfaces, wherein they assumed different names according to the parts affected; it is not my object to describe here these phenomena; I shall only prove that they are actual exhalations.

1st. I have frequently dissected subjects that had died from hemorrhage, and in this respect I have had numerous opportunities of examining the surfaces of the bronchiæ, the stomach, intestines, and uterus, but notwithstanding the precaution I had taken of washing them clean, and submitting them to maceration before I inspected them through the magnifying glass, the slightest appearance of erosion could never be found.

2dly. The following is an experiment performed on the womb of subjects that have died during menstruation, or even at other times, and which will never fail: by pressing upon the mucous surface of the uterus, a greater or less number of minute drops of blood, evidently corresponding to the vascular tubes, which on being cleared away, leave no mark of erosion.

3dly. The analogy between the other free surfaces that pour out blood evidently through their exhaling vessels, is a sufficient proof that the same phenomenon takes place also on the mucous surfaces.

4thly. The uterus in the aged female, would be nothing more than a mass of cicatrises, if rupture took place during menstruation.

5thly. In active hemorrhage, in which there evidently exists a previous congestion of blood, the laceration of these minute vessels might be supposed ; but in passive hemorrhage, in those in which the organic sensibility is annihilated, seems to admit only of a transudation through the exhalants—how could such lacerations be conceived ?

6thly. How an evacuation frequently produced with the utmost rapidity, subsiding in one part, and instantly re-produced in another, liable to every sympathetic influence, could be produced by laceration, is difficult to conceive.

7thly. Menstruation sometimes continues for a few moments, and then ceases, and in particular affections, these alternate changes occur twenty or thirty times a day; it would then require that the wounds should re-open and be cicatrised at every change.

8thly. Besides, if we compare the hemorrhages evidently produced by a laceration of the mucous surfaces, as those which in wounds on the head, proceed from the nostrils, the ears, &c., those which from a fall on the buttock will sometimes proceed from the bladder; those again, which in violent coughs arise from the bronchial surfaces; those which are seated in the stomach, when different poisons have been conveyed into this organ, &c.; let us only compare, I say, these different hemorrhages, and many others similar, which I could enumerate with those produced spontaneously on the mucous surfaces; and we shall find, that neither their phenomena, nor their duration, have the least resemblance; that their suppression does not give rise to others; that they are completely independent of any kind of sympathetic influence; that our passions, which so powerfully influence the rest, are in no way connected with their suppression, nor their production.

From all these considerations, let us conclude, that all mucous discharges, either active or passive, are real exhalations. Hence we perceive, that between the former and inflammations, there is not such essential difference as would at first appear. In the former case, in fact, there is an accumulation of blood in the capillary system, then transudation of the fluid through the exhalants that are continuous with this system. In the latter, the first phenomenon only exists. The symptoms, the accidents, &c., are certainly quite different, because the modifications of the organic sensibility are not the same, but the respective state of these minute vessels, and of the blood, are not the less analogous. A proof, that in active hemorrhage, it is the organic sensibility which, being differently modified, allows or refuses the blood to pass through the exhalants, that previous symptoms almost constantly exist, continuing more or less, and evidently denoting a defect in the vital powers, and especially of the organic sensibility. We are familiar with the sensation that precedes hemorrhage from the nose, the titillation and burning sensation previous to those of the chest; sometimes, according to the varieties of alteration in the organic sensibility, it first suffers serous fluids to transude, and afterwards those of the nature of blood. This is evident during menstruation, in which the exhalants frequently pour out for a few moments their pure blood.

In respect to passive hemorrhage, it is certain that organic sensibility, as well as the insensible organic contractility, have been reduced; we might suppose that these minute vessels cannot contract sufficiently to retain the blood; that it is the very same thing occurs as with injections which shower from the mucous surfaces, because vitality is no longer an obstacle to the transudation. It may also be remarked, that whenever these hemorrhages proceed from an organic disease, it is constantly because the part of the mucous surface that approaches nearest to the organ is influenced by it. Thus, in the last stages of the diseases of the heart and of the lungs, blood is frequently expectorated; this fluid is expelled with the fæces, or by vomiting, &c. at the termination of those of the liver; the whole of the mucous system is never at the same time divested of its powers to such a degree as to exhale blood in its whole extent, it is only impaired in a particular part.

What can dispose the mucous exhalants to give out blood in preference to the others? This appears to proceed from the capillary system from which they arise being habitually permeated with blood, and the course of the fluid stagnated in the capillaries being near to the mucous surfaces. This is so perfectly correct, that the parts of the mucous system, which in the natural state contains but a small quantity of this fluid, as those of the sinuses of the face, of the ear, &c. are less liable to hemorrhage. I am convinced that if the exhalants arose from the muscles pouring constantly a fluid over the external part of these organs, hemorrhages would be very frequent in these parts.

From what we have just stated, it is evident that the mucous hemorrhages have nothing but the effusion of blood in common with those resulting from hemorrhoidal complaints, and which always suppose veinous lacerations, or with those produced by aneurisms and varices, or by an incision, a violent fall, &c. They form a class apart and approximate to those produced by the exhalants on the other surfaces where these vessels open.

If I intended to classify the different hemorrhages, I should divide them, 1st. Into those produced by exhalation; 2dly. Those caused by laceration. In the former I should include the sanguineous perspiration, the mucous, serous, and cellular hemórrhages, &c. in the latter, those which attend wounds, aneurisms, &c. It appears to me, that to comprise all the sanguineous discharges that may occur in the animal economy, this division, which besides coincides both with the phenomena and treatment of hemorrhages, must necessarily be adopted. Would bleeding be prescribed to stop an hemorrhage proceeding from laceration? No, undoubtedly not; but we bleed to stop an active hemorrhage from the exhalants, because, by reducing the vascular mass, the excess of organic sensibility that produces the hemorrhage will also be reduced; it is nearly the same thing as when bleeding is used in inflammation. The hemorrhage must subside as it was produced; the sensibility of the exhalants must be restored to its natural type before the blood will cease to flow. Bleeding is not intended to divert the course of the blood, as it is said; if this were the case, it would be practised in passive hemorrhage. The generality of physicians, who frequently recommend bleeding in cases of hemorrhage, have thought that they were caused by plethora only, and that the vessels containing too much blood, some should be abstracted; but there are many more cases in which passive hemorrhages are not attended with the least symptoms of plethora, than cases in which these signs exist. Admitting that there is a real deficiency of this fluid in the large vessels, and that the exhalants of a part by their mode of sensibility are connected with it, they would pour out blood with the same abundance as if plethora existed. It is similar in this respect to the increase of the secretions, to that of natural exhalations, &c. If plethora in the large vessels exist or not, from the moment the mode of sensibility of the secretory or of the exhalants is increased by the local affection, these organs attract the blood in abundance. The influence of plethora over the increase of the different fluids that are separated from the blood, is evidently a remnant of the Boerhaavian opinions. If the fluids in every part were under the influence of the heart, if the blood and serum, &c. that flow from the exhalants, the secreted fluids issuing from their tubes, were propelled by this organ, this influence of plethora would necessarily exist; but since all the fluids that arise from the capillary system are not influenced by the action of the heart, that their circulation is entirely governed by the organic sensibility and tone of the capillary vessels, it is evident that these fluids must be perfectly independent of the quantity of blood the large vessels contain, and circulated by the heart; and that the alterations of the vital powers of the part, are the only causes of the various phenomena which these fluids display in their course.

We are fully aware that in females of a weak and delicate constitution, the periodical discharge is often more abundant than in those of a stronger, hardier, or more sanguine constitution, as it is called. Numerous results respecting the quantity of blood evacuated by menstruation are related by authors: it may also be observed at the same time, that none of these resemble each other; and why? because each womb is possessed of, as it were, its peculiar constitution, which frequently does not correspond with the general one, because each is consequently inclined to a different mode of vitality. More or less blood is then given in each menstruation in the same manner as this discharge is more or less continued, or as it is in some women of a serous nature, whilst others evacuate pure blood from the commencement. I cannot sufficiently repeat that every vital phenomenon is unavoidably liable to numberless irregularities, depending upon others to which the vital powers are themselves liable. Every phenomenon in natural philosophy, on the contrary, is nearly immutable, because it is the very nature of physical laws to continue the same.

From what I have just stated, it is seen how essentially the hemorrhages of the large arteries that are under the immediate influence of the heart, must differ from those of the capillary system and exhalant vessels, in which cases the phenomena, let them be caused by laceration, or by exhalation, are influenced by the powers of the part where they take place. In fact, although these two classes are, as I have stated, essentially distinguished from each other by their principal phenomena, they have some resemblance, inasmuch as the vital powers of the part will necessarily influence them from the moment they are in the capillary system. Thus, astringents, tonics, styptics, and other medicinal substances, will frequently check the hemorrhages of the capillary system. The admission of air to wounds, by modifying these properties, is frequently sufficient to produce this effect. On the contrary, the application of the ligature only in the large vessels, oppose the powerful influence of the heart. All the styptics imaginable, accumulated upon an open artery, could never prevent the effect of this influence. Such, then, is the essential difference between the hemorrhages of the capillary and exhalant vessels, and those of the arteries, that every medicament calculated to act upon the organic sensibility or tone, may be used to advantage in respect to the former, whilst it would be ineffectual in regard to the latter. I shall now proceed to the sanguineous exhalations which are performed by the recrementitious exhalants.

Hemorrhages of the Recrementitious Exhalants.

The serous membranes are frequently the seat of hemorrhages: dissection proves it in the most positive manner. Nothing is more common than to find the peritoneum, the pleura, the pericardium, imbued with a serum of a reddish hue if little blood has been effused, very deep if more has been exhaled; and even, in some instances, with pure blood.

I have made this remark in two different cases. 1st. Subsequent to inflammations, either acute or chronic, especially to the latter. The serous membrane contains, then, more or less blood; sometimes without any intermixture, most frequently mixed with serum, and occasionally even with whitish and albuminous flakes. The preceding inflammation seems to rank these hemorrhages amongst those of an active nature.

2dly. On the decline of organic diseases, when the exhalations of serum increase almost constantly in the serous membrane, even to such a degree as to produce dropsies evidently passive, more or less blood is frequently mixed with this serum. Every anatomist is familiar with these sanguineous effusions in the pericardium, the pleuræ, &c. I have noticed that the tunica vaginalis, and the tunica arachnoïdea, are much less liable to these infiltrations than any other analogous membrane ; I never met with any in the latter, and only with two instances in the former. I do not, of course, allude to those hemorrhages, the effect of wounds in the head, and where there is effusion of blood between the duplicatures of the tunica arachnoïdea.

I have carefully examined the internal surface of the peritoneum, the pleura, and the pericardium, subsequent to these kinds of hemorrhages, produced in consequence of inflammation or of organic disease : their surfaces have appeared to me perfectly sound, so that it is evident that the blood was effused by the exhalants in the place of the serum previously emitted.

I compare a serous surface, accidentally pouring out blood after inflammation, to the active hemorrhages of the mucous surfaces. On the other hand, when the serous exhalants, in the decline of organic diseases of the heart, of the womb, of the lungs, &c., pour out blood ; when, in these instances, blood received from the mucous exhalants is expectored or expelled by vomiting, by the stools, &c., they are certainly the same phenomena.

Are there cases during life, in which the blood exhaled upon the serous surfaces is subsequently absorbed? I think it may be the case after inflammation, although we have nothing positive on this head. Cruikshank and Mascagni have seen the blood absorbed by the lymphatic vessels, subsequent to wounds of the chest: why, then, should not what happens after hemorrhages through exhalation, also take place after those produced by laceration?

The cellular exhalants frequently pour blood into the cells.

1st. This phenomenon, in phlegmons, or other similar tumours, is sometimes very striking. On opening these tumours in the dead body, the extravasated blood is found in the cells: this is so perfectly true, that even some authors have set forth that the nature of inflammation consisted in this extravasation; but it cannot be that in slight cases of phlegmon, the blood remains in the capillary system of the cellular tissue; it is only when inflammation is very intense, that this transudation takes place.

2dly. In respect to the passive hemorrhages of the cellular tissue, we are aware that frequently the fluid of dropsical subjects is, in some peculiar parts, tinged of a red colour. We know that in scurvy, considerable parts of the cellular tissue are infiltrated with blood, which has certainly not been produced by erosion. I injected, not long ago, two subjects, the legs of which were covered with a very striking scorbutic eruption; in these subjects no kind of extravasation whatever had taken place in these parts, which must unavoidably have been the case if these had been produced by laceration of the vessels. As these matters did not formerly engage my particular attention, I have not paid sufficient notice to them in different subjects that I have injected, affected with these spots. I do not believe, however, they ever presented a single instance of cellular effusion: it would undoubtedly have struck me, on directing the students in their dissections, if this had been the case.

In regard to the hemorrhages of the medullary exhalants, we know of none; nor in dissection have I ever observed any effusion of blood in the articulations, except in wounds, &c.

With respect to the nutritive exhalants, it is evident they can have nothing to do with any sanguineous evacuation whatever.

Preternatural Exhalations not Sanguineous.

It is not blood only that sometimes flows through the exhalants, instead of the fluids which these minute vessels naturally convey; we are aware how much perspiration will differ: water only is sometimes transmitted by the skin; at other times the perspiration overloaded with a number of substances more or less heterogeneous, is more or less salt; we are aware of the difference in the smell. Let us only consider the innumerable substances rejected from the surface of the body by the exhalants in the course of small-pox, of measles, and of scarlet fever, &c., in tetters, in the different eruptions; or compare critical sweats with the natural perspirations, and we shall find that the exhalants are, if I may be allowed the expression, a common passage, through which every substance contained in the economy may flow, as it were, and through which, in various cases, they actually do flow occasionally, as they may happen to be connected with any of the innumerable modifications to which the organic sensibility of the skin is liable. Shall I mention the serous exhalants? A variety of different fluids are emitted from the exhalant surfaces, accordingly as they have been differently affected, the milky serum, and a dense substance that adheres to the surface in the form of a thick membrane, &c. However small may be the number of subjects we have opened that have had chronic peritonitis, we must have been struck with the diversity of fluids the peritoneum contains, greyish, yellowish, fœtid, inoffensive, thick, viscous, very fluent, &c.; they are very rarely found twice the same. The serum always appears to be the general vehicle, but the substances with which it is loaded, from the changes produced by the disease in the vital powers of the membrane, are excessively variable.

Thus we shall find the glands affording a common issue through which flow, accordingly as they are affected, a number of substances essentially differing from those by which these fluids in their natural state are performed.

SECTION IV.

Accidental Developement of the Exhalants.

The exhalants are accidentally developed in a variety of parts; in cysts especially, they are very evident. Their internal surfaces, generally smooth, shed very distinct fluids, according to their peculiar mode of sensibility. On opening these cysts, the exhalants furnish a new supply of fluids. To prevent exhalation, it frequently requires they should be removed. Sometimes, instead of the fluids they exhale, blood is produced, as is the case with the serous surfaces; for instance, I have found the serum very like blood in the incysted dropsies of the ovary; lately I have found coagulated blood. I remark that this is another essential difference between the fluids exhaled and those secreted; in fact, these are never accidentally effused in cysts; we never find preternatural collections of bile, urine, saliva, semen, &c. whilst it is frequently the case in respect to serum, as in incysted dropsies, to fat, as in steatomatous and other tumours presenting a greasy substance similar to that fluid, or to synovia, as in the ganglions, whenever they are not synovial dilatations, but present cysts accidentally produced, &c. From whence proceeds this difference? The reason is, because, that the secreted fluids should be thus accidentally separated from the blood, it would be requisite that glands should be also accidentally formed in the body. Now the structure of these organs is too complicated, their organization admits of too many conditions for this developement to take place. The simple organization, on the contrary, of the exhalant surfaces in which there are merely vessels continuous with the arteries, without any intermediate organ, require much less labour to be thus accidentally produced in parts in which they were unknown before.

Sometimes the preternatural fluids are not collected in a cyst, they always flow externally: such is the case with fistulas and other natural or artificial issues. Then the cellular tissue always preserving the accidental modification of sensibility produced in a part by an abscess or any other cause, still continues to pour a fluid different from that exhaled in the natural state.

ABSORBANT SYSTEM.

This system results from the assemblage of a multitude of minute vessels that arise from all parts of the body, from which they return various fluids, which they pass over into the dark blood, after having circulated them through particular bodies called lymphatic glands, which form a part of their system. The whole of the absorbant system then, includes, 1st, The vessels; 2dly. The glands:—an incorrect expression, as it assimilates, as it were, the organs it describes with those that pour fluids through the excretory vessels arising from them.

ARTICLE I.

Absorbant Vessels.

We shall examine these vessels in their origin, their course, and in their termination.

SECTION I.

Origin of the Absorbents.

The origin of the absorbents can with difficulty be demonstrated by inspection; they are in this respect similar to the termination of the exhalants. Such, in fact, is the excessive tenuity of these small vessels at their origin, that in almost all parts they escape unnoticed, even to the eye, assisted with the best optical instruments. Pores, in fact, are perceived in some parts; but it is difficult to show if they are absorbents or exhalants. The origin of the first must then be established by the phenomena they produce in different parts. Wherever absorption is carried on, it is evident there they begin. Now, on examining attentively the phenomena of absorption, it is observed wherever exhalations exist, so that the same table might serve for both. This is the table for the first of these functions.

ABSORBANT VESSELS.	1st. External, arising from	1st. The Mucous. 2dly. The Dermoïdal systems.	
	2dly. Internal, arising from	1st. The Serous system. 2dly. The cellular from which they take up.	1st. Fat. 2dly. Serum.
		3dly. The medullary system.	1st. Of the short, of the flat, and ends of the long bones. 2dly. Of the middle of the long bones.
		4thly. The synovial system.	1st. Of the articulations. 2dly. Of the tendinous grooves.
	3dly. Nutrition.		

Let us return to these different absorptions. Here I shall not enter into minute particulars to prove their existence, because these proofs will be produced in every system from which the absorbents arise; 1st. The external absorptions do not exactly correspond with the exhalations of the same nature: in fact, it is not sweat, nor the imperceptible perspiration exhaled by the skin, that are taken up by the cutaneous absorbents; these fluids are excrementitious. In the same manner the mucous absorbents suffer the pulmonary perspiration to evaporate, and the other fluids exhaled over their surfaces to mix with the food, to be afterwards expelled. The substances which the atmosphere and surrounding bodies contain, are, as we shall see, those selected by these vessels from an excessive irregular absorption, except, however, that of chyle, which is not absorbed in an uninterrupted manner, but is sometimes rejected, at other times taken up with remarkable activity.

2dly. The internal absorptions, on the contrary, correspond in all the parts with the analogous exhalations. Thus the absorbents take up serum, from the serous system, serum and fat from the cellular system, marrow from the medullary system, synovia from the synovial system; fluids which had all, as we have seen, been exhaled and retained for a time upon their respective surfaces, and such absorptions are performed in a constant and regular manner, an essential distinction between them and the preceding. The interior absorptions incessantly acting, take up at the same time the same quantity of fluids; their action exactly corresponds with that of the exhalants. It may be noticed, that there is a two-fold, and essential difference between the external and internal absorptions; namely, that on one hand the first act upon fluids distinct from those deposited on their surfaces, and that on the other hand they are liable to variations and constant irregularities, whilst the others, on one part, always take up the fluids effused over their surfaces, and on the other, are incessantly and regularly performed, at least in the state of health. When treating of the mucous and cutaneous systems, I shall point out the cause of this important distinction.

3dly. In respect to the nutritive absorptions, we are not quite so familiar with them as with the preceding; but nutrition evidently demonstrates their presence. In this function, in fact, there are actually two motions, one of composition, the other of decomposition; each organ, each part of an organ, are no longer at a certain epoch formed with the same elements they were composed of previously. The ancients supposed, but the opinion was unsupported by positive proofs, that the body was renewed every seven years. Whatever may be the epoch of this restoration, it cannot be disputed but it is habitually composed and decomposed: now the exhalants answer to this first nutritive motion, the absorbents are intrusted with the second. We may remark, in fact, that the internal substances are never returned into the circulatory torrent to be subsequently expelled but by means of the absorbents.

The nutritive absorptions then differ from the preceding, inasmuch as the substances deposited by exhalation and taken up by them stagnate in the organs, and contribute to their composition, whilst the fluids submitted to the internal exhalations and secretions, after having been produced by the one, and before they are taken up by the other, stagnate on the external part of the organs, over their surfaces, or in their cells, but without contributing to their structure. It will perhaps be found difficult to conceive, how solid nutritive substances can possibly be absorbed by such very small tubes. Hunter, to whom anatomy is so much indebted, in respect to the absorbents and their intended purposes, has already resolved this question and removed the objection. To what he has advanced may be added, that the distinction between the solids and the fluids exists only when they form a mass; but that when alluding to their divided particles, they do not differ from each other: this is so perfectly true, that the very same particle will alternately form a part of a fluid or of a solid, such as in water in its usual state or after being congealed, in lead either in a solid or fluid state, &c. &c. Now since it is by separate particles that the nutritive substances are absorbed, then in the absorbant function no distinction between the fluid and the solid exists.

Since the origin of the absorbents is concealed from sight, it is difficult, nay even impossible, to determine how they arise, to ascertain the structure by which they are distinguished. In their origin, in their communications, &c., they must certainly differ essentially in the mucous, cutaneous, serous, synovial, cellular, and medullary surfaces, to which they belong: the nutritive exhalants also must differ materially from the others; but nothing can be elucidated by inspection. What has not been said in respect to the intestinal villi considered as the origin of the lacteals, to their swellings, the pores of the peritoneum, of the pluræ, &c. the spongy nature of the cellular membrane? I shall pass over these anatomical hypotheses, in which the microscope has been condemned, and which besides, admitting even that they rested on some solid foundations, could lead to no inference useful to the science.

Do the absorbents arise from the capillary system? Injection seems to prove it, as several reputed anatomists, by injecting the arteries with very liquid fluids, have filled the adjacent absorbents. I have never observed any thing of the kind myself. It is very far, however, from my intention, to deny a fact ascertained by Meckel, if it were supported by repeated experiments, would evidently and indisputably prove that the absorbents arise from the capillary system, as it proves that the excretory and the exhaling vessels arise from the same system. The phenomena of absorptions, however, can throw no light on the mode of origin of the absorbents.

On proceeding from the surfaces or from the organs whence they arise, the absorbents are remarkably small; they baffle injection of any description: they appear to anastomose with each other, to interweave, and to form an intricate plexus, essentially contributing to the structure of certain parts, especially of the serous membranes. We are, however, but imperfectly acquainted with this mode of distribution, it is only after having overrun some extent, that these vessels become perceptible, and consequently that they admit of being generally studied.

SECTION II.

Course of the Absorbents.

ARISING from the various parts that have just been described, the absorbents proceed in different directions.

1st. In the extremities, they instantly divide into two very distinct layers; the one superficial, the other deep. Those of the first layer immediately accompany the sub-cutaneous veins, and twine in the interstices, so that whenever injections have proved successful, the whole external part of the limbs appears enveloped by a lymphatic coating. Those of the second entwine in the muscular interstices, chiefly in the course of the arteries and veins: both of these divisions are directed towards the upper parts of the extremities; their vessels approach and unite into a bundle, in which they are less numerous, but larger, and which, having passed through certain apertures, proceed within the trunk; for instance, nearly all those of the superior extremities are united in the axilla: those of the inferior in the groins, and some in the ischiatic foramen. Now as it is a general rule that all the absorbents should cross one or several glands, nature has provided the communications between the limbs and the trunk with a certain number of these glands. Some, however, before they reach them, have already crossed similar glands, situate, though in a smaller number, in the ham, and in the fold of the arm. It is in the extremities, the absorbents are seen to pass to the greatest distance without crossing glands.

2dly. In the trunk, the absorbents at first form two layers; the one sub-cutaneous, the other deep, found on the internal surface of the parieties of cavities: for instance, in the abdomen, between its parieties and the peritoneum; in the chest, between its parieties and the pleura; the first division especially proceeds from the fleshy parieties, and the abundant cellular tissue adjoining: the second belongs both to these parieties, and to the serous surfaces with which they are lined. Besides these aborbents, all the viscera contained in the preceding cavities are also provided with some, both deep and superficial: the former even in the very interior of the organ: the latter are seen over its surface. This distinction is easily made in the liver, in the spleen, &c.; the external absorbents of the trunk run a tolerable distance without meeting with any glands. Those that twine over the internal surfaces of these parieties are similarly disposed; but such as proceed from the viscera, on their egress, meet with these glands, and cross them several times because they are situate close together.

3dly. Many absorbents are found on the external part of the cranium; but anatomists have not yet succeeded in finding any within its cavity, which, perhaps, agrees, as I have before stated, with the almost total absence of cellular tissue in this cavity; many are found in the face, either superficially or in the muscular interstices, and round the organs situate in that region; they proceed to the neck, and meet in their course a number of glands, which they cross in succession.

Forms of the Absorbents in their Course.

The absorbents differ essentially from the veins, in preserving the same volume for a considerable distance, whilst the latter progressively unite into larger trunks, and a branch scarcely extends a few inches before its volume is double; but that of the absorbent remains the same. When injected, these vessels at a distance appear like white threads curling over the organs.

From this it follows, 1st. That the lymph never circulates like the blood in considerable columns, but always in very minute streams.

2dly. That the absorbents are very much multiplied; their number compensating for the size: thus it is that every surface is crowded with them, whilst the veins, united into trunks, are more sparingly distributed.

3dly. That the absorbant system is not disposed in an arborescent form, like the arterial and veinous systems; the mode of division is completely different. The absorbents are very often straight; whenever this is not the case, their curvatures are quite different from those of the arteries and veins. In fact, when these become as small as the absorbents, their frequent curvatures are in proportion to the size of the vessels. The flexures of the absorbents, on the contrary, are large; when they are not straight, they are seen to twine in large folds over the extremities; viewed internally, the absorbents are not always perfectly cylindrical. When injected, they frequently display knobs, which undoubtedly proceed, in a great measure, from the valves. Several others have represented them as a succession of contractions; this, however, is only correct to a certain degree.

Those I have frequently met with in living animals, in dogs in particular, were visible dilatations, a kind of vesicles, occupying the course of a lymphatic, and containing serum. It was on the concave surface of the liver, and on the vesicles, that I have most frequently made these observations. On puncturing these vesicles with a lancet, the fluid passes out, and they instantly disappear. On trying experiments with other views, I once saw two or three of these small dilatations near the gall-bladder; having dropped the liver to examine the intestines, I was much astonished, shortly after, to find them no more: they had disappeared undoubtedly from the contraction of the vessel. I have remarked in this respect, that the liver is the organ in which these kinds of vessels are better ascertained in living animals; but at the very moment the abdomen is opened, the concave surface must be examined, because the contact of air, by contracting them, will soon conceal them from the sight.

Besides, I do not believe, that during life in any instance whatever, the absorbents are as much distended by serum as they are by mercury, subsequent to injection. When injections have completely succeeded, a very distinct plexus of vessels is seen over several parts. Nothing similar to this, on the contrary, is ever met with in living animals. However quickly the greatest part of the surfaces that cover the serous membranes may be examined, surfaces that can never be laid bare without an effusion of blood, nothing can be perceived, except occasionally a few small transparent striæ, which soon disappear. If the absorbents were filled during life, as they are when injected from their transparency, contrasted with the surrounding parts, it would be impossible they should not be conspicuous. I had selected very large dogs, the better to ascertain the course of these vessels, and I believe that their size is at least doubled by injections.

Capacity of the Absorbents in their Course.

The capacity of these organs varies remarkably: in the dead body it absolutely depends upon the state of these vessels at the last moments. In two different subjects, similar both in stature and age, they are sometimes more apparent, at other times scarcely perceptible. In peculiar dropsies they are found increased to double, or even treble, their natural state. Several authors have stated that they have seen branches nearly equal in size to the thoracic duct, and superior to the trunk of the right ride. To ascertain accurately the immense number of the absorbents without the help of injections, we should select the lymphatic glands in different parts, then dissect with attention the surrounding parts, and the absorbents that resort to these glands will be found without difficulty. We may then be convinced of the great variety in their size, and although not injected, they may, by this method, be traced to a considerable distance. Sometimes, in order to find the end of the thoracic duct, I used to select a gland near the second lombar vertebra, then by following the empty lymphatics that proceed from this gland towards the duct, I have found it without the least difficulty.

With those that are not in the habit of finding the absorbents immediately this method must infallibly succeed; it cannot, in fact, be made use of in the extremities; but in the chest, and in the abdomen particulary, it affords great facility: for instance, in passing from the inguinal glands, these vessels may be traced as far as the thoracic duct, either by injecting them, or even without this process. Some authors have recommended to fix the tube in the gland by an incision. This will seldom succeed. It is much more advisable to open the vessels at their exit from the glands. The absorbents being generally compressed in the dead body, in consequence of not containing fluid, will never present in that state a diameter proportionate with that which they derive from injections; whatever may be the varieties, in capacity it is always increased by the impelled fluid. It is their state of collapse after death, that in attempting to open them with the lancet, so frequently causes both sides to be divided, and consequently produces more difficulty in injecting them.

The best proof that can be afforded of the extreme variety in the capacity of the absorbents is the unavoidable necessity of selecting peculiar subjects for injecting, and the great difficulty of discovering these organs in some subjects, whilst in others, by tracing them through the cellular tissue in the lower and upper extremities, they are easily discovered without the aid of glands. We should not then, from what I have stated, consider the capacity of the absorbents in a determined manner; always varying according to the state of the contained lymph, they do not admit of a medium to which their increase or diminution can be referred. It is the nature of every canal which, like those of the economy, admit of extension and contraction, and it explains why they necessarily baffle every calculation in respect to capacity.

These varieties in the absorbents are not general as in the veins, in which vessels, the large trunks for instance, are simultaneously dilated whenever obstruction exists in the lungs. Here it is sometimes a single branch, at other times several are increased in diameter, the others remaining contracted. In some instances, the dilatation in a part is general, the same vessel often displaying an astonishing disproportion in its capacity; although it has received no branches, one part is double the size of another.

Authors have been much at a loss how to ascertain the capacity of the thoracic duct. At this I do not wonder, for it is never found twice the same. These variations do not proceed from the constitution of the subject, but solely from the functions, and from the state of these functions at the instant of death. Whether in these variations they are dilated at the upper part or contracted in the middle, or the lower part terminates in a swelling, termed by some the reservoir of the chyle, &c., they are constant during life, according to the quantity and nature of the lymph, and the obstructions it has met with in its course in any part. In a hundred different subjects we shall find a hundred varieties in the thoracic duct and the absorbents, and the very same subject has probably experienced, during life, all these varieties. If in the same subject life could be frequently re-produced and annihilated, the variations of the veinous and absorbant systems would probably be as numerous.

From these considerations, it is seen how useless have been all those idle comparisons of proportions between the capacity of vessels with which books on physiology are crowded.

If the assemblage of the veins be compared with that of the absorbents, from what I have just stated, it is certainly very difficult to obtain any accurate information, but some approximation might be admitted. Now the absorbents do not appear much inferior to the veins: for instance, the sum of the lymphatic vessels in the inferior extremities, compared with the capacity of the veinous trunks, is not much less. It is the same in every other part, the veins being larger, but the absorbents more numerous, the disproportion is not very material.

From this, it would appear, there should be no great difference between the trunks in which the veins terminate, and those which form the boundary of the exhalant system; this difference however, as we shall see, is enormous.

Anastomosis of the Absorbents in their Course.

In the extremities, the external parts of the trunk, and of the head, in the intermuscular spaces, &c., the anastomosis is very striking. The communicating branches are seen projecting from one vessel to another; so far even, that we might frequently be led to believe these vessels bifurcate, but this is most generally illusory, for each branch of the division is nearly always as thick as the trunk.

Under the serous surfaces, as in the convex surface of the liver, of the lungs, of the spleen, &c., anastomosis is much increased: in plates they represent plexuses, for I must confess I have never injected this part of the absorbant system.

Anastomosis is produced in the absorbant system.—

1st. From one vessel to another that is contiguous.

2dly. In the membranes, from the sub-cutaneous divisions to the intermuscular, and in the organs from the sub-serous divisions, to those situate in the interior of these organs.

3dly. They exist between the absorbents of the upper regions, and those of the inferior.

4thly. Between those that proceed to the thoracic duct, and those which resort to the great lymphatic vessel of the right side, &c.

By this anastomosis it is explained why, when the tube containing mercury is placed in an absorbent, many others around it are filled. This mode of union is the more necessary, because the course of the lymph, like that of the dark blood, in consequence of not being provided with an impulsive agent, is liable to be obstructed by a variety of causes.

Gravity, the external motions, the different compressions, &c. particularly the first of these causes, have the same influence upon this fluid as upon that in the veins. It is well known that subsequent to long continued diseases, however little the strength be reduced, an upright posture continued causes the legs to swell: this explains why in this instance they are always more swelled in the evening than in the morning. With regard to compression, there is not a single one, if rather strong and including many absorbents, but will also produce swelling. It is not the extent of the surface compressed that produces this phenomenon; it is only the number of the absorbents with which the surface is supplied: thus the displacement of the head of the humerus, by sliding in luxation under the arm-pit, frequently causes the arm to swell, whilst compressions of greater extent, on a level with the deltoid muscle, where but few absorbents are met with, does not produce that effect, &c.

For these reasons, it was requisite that the same means should exist to promote lymphatic circulation, as to facilitate that of the veins. Anastomoses, in particular, afford these means, through them the former of these motions is continued, notwithstanding the pressure of our clothing, in different parts of the body, and of the viscera upon each other. Thus, the womb being much increased in pregnancy, weighs heavily upon the lower extremities, and frequently causes infiltrations in those parts. I see no other internal organ, that like this, might, on account of its situation, occasion, by its pressure, these general infiltrations. The liver and the other organs are not calculated to produce a similar phenomenon; whenever dropsy proceeds from affections of these parts, it is rather from the increased action of the exhalants that the evil proceeds.

Remarks on the difference of Dropsies, accordingly as they are produced by an increase of Exhalation or deficiency of Absorption.

This, in respect to dropsies, leads to a point that appears to me of the utmost importance, namely, to ascertain when these affections are produced by a want of action in the absorbents, and when they proceed from an increased action of the exhalants.

When a ligature too tightly applied to a limb produces swelling in the inferior part, when a particular posture too long continued, a perpendicular position of the upper extremities, &c. produce the same result, &c. it is supposed that the infiltration proceeds from the compression of the lymphatic vessels, and that it is then produced in the same manner as in the dilatations of veins in similar instances, because the circulation of the lymph is obstructed. This, then, is one instance in which exhalation does not interfere with dropsy, and which has occurred because the absorbents do not take up what they had supplied.

If other causes, such as a bruise, a wound, &c. lessen the powers of the part, the absorbents directly injured cannot act. If their enfeebled state proceed from sympathy, that is to say, if it depend upon an injury to some viscus, a similar phenomenon is the result. In all these instances, the absorbents are found considerably dilated in the dead body, they are even frequently seen filled with fluids.

2dly. In organic affections, however, when a dropsical complaint ensues, there can be no doubt, at least in the greatest number of cases, that it depends upon the superabundant discharge from the exhalants. In phthisis the pleura is loaded in the same manner as the skin is covered every evening with perspiration, or as blood is expectorated, &c. Such are the exhalations I have denominated passive; they are so certain and copious upon the serous surfaces, that if a puncture were made the peritoneum would often be filled again with such excessive rapidity, that the fluid collected in a single day would require a month and more to be exhaled in the natural way. I do not pretend to say, that, in such cases, the absorbents are not also affected; but the principal cause of dropsical complaints in such cases rests with the exhalants. I might produce other instances, but this will suffice. About four years ago, I had directed my attention towards the absorbents; it then struck me that these vessels, notwithstanding what several authors had asserted, were not always very apparent in dropsical subjects, and that they often admitted of an easier investigation in a very lean subject. This distinction in dropsical cases had not then occurred to me; but on re-considering this system for the book I intend to publish on descriptive anatomy, I certainly shall attend to it, and compare the cases of its dilatation, and those of an opposite nature, with the cause of death.

SECTION III.

Termination of the Absorbents.

All the absorbents that have been discovered, proceed to form two principal trunks. The first, the thoracic duct, includes all those proceeding from the lower extremities, and from the abdomen, those of a part of the chest, and of the left side of the upper parts. The absorbents of the right side of the upper parts, both of the head, as well as of the extremities, and a few of those of the chest, contribute to form the other. These two principal trunks open into the vena cava superior; around these several small vessels also resort to this trunk.

However slightly the quantity of absorbents distributed throughout all our parts be examined, the enormous disproportion in capacity, when compared with that of these two trunks, will, as I have previously stated, be easily conceived. How then can it happen that the whole of the serum spread over the serous surfaces, or contained in the cellular tissue, all the residue of nutrition, medullary juices, synovia, that every kind of liquid, and the whole produce of the solid food, incessantly admitted into the torrent of circulation, must, before they can reach it, flow through such very minute tubes? Authors have been struck with this observation. I confess it is a question replete with difficulty. In fact, 1st. When a disproportion exists between the blood vessels, where the diameter is reduced the rapidity increases, and compensates for the difference; thus, although the capacity of the veins exceeds that of the pulmonary artery, the whole of the blood contained in the former flows through the latter. Now, if during the process of digestion, the thoracic duct be examined in a dog, an investigation easily effected by opening suddenly the right part of the chest, and lifting up the lungs in that part, and by dividing the pleura in the course of the aorta, by which means that canal which, on account of the chyle that circulates within, has a whitish appearance, is instantly perceived; if, I say, the thoracic duct be studied when in action, circulation will be found to take place nearly in the same manner as in veins. On dividing it then, a larger stream does not denote a more rapid motion than that of the dark blood. 2dly. It might be said, that during life, the thoracic duct is sufficiently dilated to correspond with all the absorbents; but observation proves the very reverse. This canal, filled with chyle, is certainly rather more dilated than in the dead body, but I have ascertained that the difference is not very material. 3dly. By supposing that notwithstanding its very limited capacity, a considerable quantity of fluids may flow through the thoracic duct, the vena cava superior should be more dilated between this organ and the heart; however, it is nearly the same after the junction. 4thly. Heuson, by emptying the lymphatic vessels, has proved that the contained fluid is analogous to that of the serous surfaces: its transparency, which is not, however, a positive reason, when examined in the vessels of a living animal, has also led me to think so. How then can it be accounted for, that this fluid can be the result of an assemblage of such different elements, namely, of those which constitute the mucous, the cutaneous, the nutritive absorptions, those of fat, &c.?

I grant, that the different substances admitted into the circulation of the dark blood through the thoracic duct, and the corresponding one, may be received in turns; that the lymph, fat, chyle may each have their particular moment to join the circulation, but this explanation is not supported by any fact, and even then, the disproportion would still be very considerable.

A great number of distinguished anatomists have thought that the veins are capable of absorption, and in respect to this function, they have associated them with the lymphatic vessels. Haller, Meckel, and prior to them, Kaw, Boerhaave, were of the same opinion. Such names, undoubtedly command a mature consideration of the arguments produced; let us then proceed to consider them.

1st. The thoracic duct has been seen obliterated, and yet absorption continued, since the subject survived; but as it had not been observed whether the great right lymphatic and accessory vessels were also obliterated, no conclusion can be drawn from this fact; besides, I do not think that the observations on this important point are sufficiently correct. It appears to me, that this question might easily be decided by applying a ligature during digestion, to that part of the thoracic duct where it enters the jugular vein: we might find it at the lower part of the neck, where its whitish appearance would prevent a mistake, and no essential part would be injured. This experiment would cast a strong light on the general question respecting the absorbents.

2dly. Very liquid fluids injected into the meseraic vein, are diffused over the peritoneum; from this fact, it has been concluded, that the absorbents terminate in this vein: but as the veins terminate in the capillary system, and from this the exhalants arise, the injection by crossing its innumerable anastomoses might easily have found a passage that did not exist during life, but which from the laxity of the parts and the want of sensibility is open after death.

3dly. The compression of the superficial veins produces infiltration of the extremities, but as such compression operates at the same time upon the absorbents, no inference in regard to veinous absorption can be deduced.

4thly. Kaw and Boerhaave having injected the intestinal canal with water, the fluid was found in the meseraic veins; but this experiment repeatedly tried since, has never been attended with the same result.

5thly. To prove that there is no veinous absorption on the surface of the intestines, may be added to these considerations the numerous experiments of Doctor Hunter, and we shall find that this mode of absorption will, in these respects, appear very uncertain.

If, however, the question be viewed in other respects, it cannot be denied that some facts rather favour this opinion.

1st. It is almost certain that the extremities of the veins draw the blood, as it were by absorption from cellular bodies.

2dly. No absorbents have been discovered in the placenta and still the umbilical vein receives also the fluids it contains.

3dly. Meckel, having injected a lymphatic vessel resorting to a gland, the injected mercury proceeded to an adjacent vein.

All these observations still leave the termination of the absorbents in obscurity. It is my opinion, that if on the one hand, it cannot be doubted, that the greatest part of these vessels, particularly those which proceed from the serous surfaces, from the cellular tissue, the intestines, &c., have particular terminations, on the other hand, we ought to suspend our judgment respecting the mode in which the others terminate, and that in this respect, the question must remain perfectly undecided until elucidated by further experiments. In this respect, as well as in many others, physiology is still in the dark. In fact, we find;

1st. An enormous disproportion between the absorbents and their common trunks.

2dly. The impossibility of conceiving accurately, the lymphatic circulation from the analogy of veins, with the apparatus displayed by injecting these vessels.

3dly. There are numerous probabilities against, and a few in support of veinous absorption.

4thly. No other means of communication, besides the trunks above stated, for fluids penetrating from the absorbents into the blood, are yet ascertained. In the different theories adduced to resolve this question, there is nothing but obscurity and contradiction.

SECTION IV.

Structure of the Absorbents.

This structure, admitting of investigation in the large trunks only, for instance, in the thoracic duct, first displays in its common organization, a layer of that dense cellular tissue, already so frequently described, and still to be noticed, which is found around the arteries, the veins, the excretories, under the serous surfaces, &c. &c.

This filamentous tissue, unconnected in some degree with the vessel, strengthens it, however, by forming an exterior membrane, superadded to that peculiar to its structure. If, as Cruikshank has done, the duct be turned backwards, and a glass tube rather superior to it in diameter be introduced, this membrane breaks. It is the very same thing as when a ligature applied to an artery, divides the internal membrane, and leaves the cellular one uninjured; a similar phenomenon is produced by inflation, a much more powerful exertion is then required to divide the cellular tissue than to lacerate the proper membrane of the thoracic duct.

No fleshy fibres are ever observed, at least in a conspicuous manner, in the absorbents. A few authors have admitted them, but their assertion has been contradicted by inspection, even in the thoracic duct. It is probable, that the parieties of the absorbents are over-run with blood vessels; in common injections, they are frequently evident on the thoracic duct, but it is not known whether they are provided with nerves; if we judge by analogy with the veins, to the structure of which they bear a striking analogy, they must be very obscure, admitting that they exist.

The internal membrane that forms the tissue peculiar to the absorbents, is continuous with that of the veins, and forms with this an uninterrupted continuation of minute tubes. Delicate and transparent, it is moistened in the dead body by an unctuous fluid that is not, I believe, found during life, in the same manner as that of the arteries is in respect to these vessels. It adheres to the external membrane by a tight cellular tissue, which, as in the veins, very seldom becomes ossified. Mascagni, however, quotes an instance of it, relating to the absorbents of the pelvis; but there is another kind of affection analogous to this, and which I have already frequently seen in these vessels. Their cavities are often seen to contain a white matter, similar to plaster, particularly on the external surface of the lungs. In such instances, without any kind of preparation, the absorbents present nearly the same aspect as if they were filled with mercury.

The proper membrane forms, by its reflexions, valves similar to those of the veins, but much more numerous; they are united two by two, and are rarely found single. They leave between them very short spaces, but of very different extent. This explains why the thoracic duct sometimes admits of being injected from above downwards throughout its whole extent, and on other occasions receives the fluid only in a short space, accordingly as the valves are more or less multiplied in its cavity; this also depends upon the connection that exists between the width and the diameter of the vessel, a connection that varies by the same causes as those assigned in respect to veins. Hence it is, that an isolated absorbent, filled with injection, may present either none, or a considerable number of these knobs, that prove, as we have previously stated, the existence of valves. Where a branch joins a trunk, two of these folds are found at their junction; this is very remarkable in the thoracic duct, which, being injected from above downwards, presents a dilatation in the origin of every branch, because in these parts the valves have checked the course of the fluid. Rather scarce in the superficial system of organs enveloped in serous membranes, as on the convexity of the lungs, of the spleen, they readily admit of the transition of mercury from one division to another, and are assisted in their functions by the extensive anastomoses which these parts contain.

Their use is similar to that in veins, namely, to accommodate the ascent of the fluid, and prevent its return; but they do not at all times completely fulfil this purpose, as some are frequently forced by injection. In dropsical cases, in which the absorbents are filled, on lifting up the skin, the transparency of these organs renders it easy to distinguish them, but they soon empty notwithstanding their valves, and then become imperceptible. Several anatomists, by means of the thoracic duct, have inflated or injected, with other fluids, a number of lymphatic vessels, consequently, in opposition to the valves? All these phenomena do not imply varieties in the structure and dimensions of the valves, in respect to these tubes, as to their common canal, &c., but only different degrees of dilatation or contraction; degrees that are themselves, as I have said, independent of their structure. When dilated, the valves do not so completely fill up the diameter of these vessels as when they are contracted.

The valves of the absorbents have the same form, and are disposed like those in veins; in not being constantly free from ossification, they partake of the general character with the membrane from which they arise, and by the folds of which they are formed.

ARTICLE II.

Lymphatic Glands.

SECTION I.

Situation, Volume, Form, &c.

These glands are distributed throughout the different parts in a greater or less number. A few only are met with in the upper and lower extremities, unless it be near the trunk, as in the groins, arm-pit, &c. Some are seen in the pleat of the ham, and of the elbow. Some even have been engraved in plates over the footstep; but in the arm, fore-arm, leg, and thigh, none can be discovered. On a level with articulations, they all meet; it might be said in this respect, that they gradually increase from the lower to the upper parts, because, on ascending the number of absorbents progressively increases.

There are few on the cranium, and these are always found externally; the interior of this cavity has never I believe been seen to contain any, a circumstance that might perhaps tend to prove, it is not on account of their excessive tenuity that the absorbents are concealed from sight, but because in this part they are of a peculiar and distinct nature from that of others. The face is abundantly supplied with a number of these glands, particularly along the stenonian line over the buccinator, &c.

In respect to the trunk, if the vertebral column be selected for the ultimatum of comparison, the lymphatic glands are found very scarce, even deficient in the posterior part, but considerably multiplied in front. In the neck the jugular veins are attended with a numerous string of these kind of glands. In the chest the mediastinum is provided with a tolerable number of these organs. In the abdomen, under the mesentery they seem excessively multiplied along the vertebral column.

The whole of the thoracic and abdominal cavities, viewed in any other part than anterior to the spine, is also abundantly supplied. A number of these glands are found accumulated in the mesentery, at the origin of the lungs, round the bronchiæ and in the pelvis. From such disposition we perceive that,

1st. The lymphatic glands are in general more multiplied in such parts where the cellular tissue, in which they are in some measure immerged, is more abundant; a very remarkable connection, for which we can assign no precise cause. There are few parts in the economy in which this tissue is abundant that do not also contain these kind of organs, and reciprocally wherever the tissue is deficient the absorbant glands are wanting.

2dly. It is also observed that such parts as are more distant from the common absorbents, as the head, the extremities, &c., are more sparingly provided with them; that the nearer we approach these common trunks, the more these glands are multiplied; so that it might be said they form around them a kind of limit by which they are separated from the absorbents of a second order, insuring at the same time the means of communication between them.

The size of the lymphatic glands varies from the tenth part of a line in diameter to the size of a filbert; they are frequently so very small that they are hardly perceptible and are often concealed from sight, if not developed by disease. Their increased size is a usual effect of scrofula, which frequently displays to us lymphatic glands in parts where they had not been previously observed, as in certain parts of the face, especially of the neck. It cannot be said that in such cases we are deceived by masses of cellular tissue, for by comparing these bodies thus developed in disease, and which undoubtedly pre-existed, together with the lymphatic glands already known, also in a state of obstruction, they are perfectly similar, each of them exhibiting the very same whitish and greasy substance, or the same cheesy pus, according to the period of the disease.

In general, these glands are much developed in the infant, diminished in the adult, and almost lost in the aged subject. It has appeared to me they were rather more striking in the female than in man, and more so in those of a phlegmatic than of a sanguine temperament. Amongst the different obstructions of which they are susceptible, the careau is that in which they generally attain the largest size.

Their form, sometimes oval, at other times more or less oblong, is always spherical, a form towards which, not only the organs of animals, but even all those of organized bodies naturally tend; whilst the cubic and prismatic forms more generally belong to unorganised bodies.

The lymphatic glands, sometimes insulated as in the furthest parts of the extremities, gradually accumulate as they approach the common trunks. A considerable number, as I have previously stated, are contained in the loins and in the axilla, but in the abdomen they are grouped together, and are so crowded round the mesentery, that to Azelli they appeared to form in that part not a union of organs, but one single organ, which he mistook for a second pancreas, and designated with his own name.

SECTION II.

Organization.

The colour of these glands, reddish in the infant, greyish in the adult, assumes in the aged subject that yellowish tint, that diminution and laxity, which at that stage characterizes nearly every organ. The colour also varies according to the different regions. Thus the bronchial glands have a blackish colour, partly allied to their structure, but probably owing also to the fluids they contain, which is proved by the inspection of that fluid when pressed from the divided gland. It does not proceed from the vicinity of the lungs, nor from that organ being spread over, as is well known, with blackish spots; the proof is, that I have already found the lombar and mesenteric glands, &c. of the same colour. There are no parts, however, where this colour is more frequent than on approaching the lungs. Cruikshank, to prove the passage of the lymphatics through the glands, asserts that he has found those adjoining the liver in jaundice, of a yellowish colour, in which it is probable that bile was absorbed. This remark, however, is of little importance, since every part in the economy, without exception, is in this affection of the same colour, only it is more striking in the cellular parts. It cannot, however, be denied that these glands frequently assume a colour similar to that of the fluid with which the absorbents, either in the natural state or when injected, are filled, on account of the great number of vessels that penetrate within. During digestion at the time the lacteals transmit the chyle, those of the mesentery become nearly as white as that fluid, and when this is completed, they soon acquire their usual colour: a similar phenomenon is produced by filling the absorbents with mercury.

Parts in Common.

The structure of those parts common to the lymphatic glands is as follows:—they are inclosed in a slack, extensible, and very abundant cellular tissue, that accommodates their motion, and admits of their being displaced when pushed by the finger. Hence that very remarkable mobility observed in the greater part of these organs in the early periods of their obstructions, when that tissue has not itself been yet affected, they partake of the injury, gradually become less flaccid, and adhere to the surrounding parts. Thus, at first moveable in cancer, these glands are subsequently fixed: they are generally immovable also in cases of acute inflammations, because the adjacent tissue has partaken of the disease.

The cellular tissue besides supplies the glands with a dense membrane that envelopes them in a more direct manner, and which membrane, not being provided with fat and serum, appears of the same nature as the cellular covering of the absorbents. It is this membrane, that in the natural state gives to the gland in general a smooth and polished appearance, for, when injected, mercury discloses in these organs a few asperities, owing to the projection of the vessels with which they are internally supplied. A few slight depressions are also observed over their surfaces; these depressions are to the glands, what the furrows of the concave surfaces of the liver, spleen, and the lungs, are to these organs; it is through these the vessels penetrate them; if guided by injections that totally colour the glands when the fluid is very liquid and the operation dexterously performed, arteries might be supposed very numerous in these organs; but how little we should rely upon such means as have been already accounted for; the mere inspection of a living animal, a much safer guide, displays in these glands but a very small quantity of blood. In the fœtus and in the infant a greater quantity of this fluid is observed; hence in part proceeds the redness that characterizes the organs at that stage of life. It is not known whether these glands are supplied with nerves, and if some of the numerous ramifications that proceed from the ganglions in the adjacent parts, the mesentery particularly, penetrate their tissue: I have never traced any.

Proper Tissue.

The substance proper to the lymphatic glands presents a pulp analogous in some degree to that of the nervous ganglions. The least fibre cannot be discerned. Soft in the fœtus, nearly shrunk from the small number of glands remaining in the aged subject, this substance is, as I shall prove, very much altered by scrofulous diseases, and by the influence of disease in the adjacent parts.

This tissue is more or less dense; the superficial glands are more solid, and resist the injection of mercury much better than those deeply situate; they contain cells in different parts, especially in the infant, and a whitish fluid, that together with the cells disappear as age advances. This fluid of a peculiar nature, can be compared only with those of the thyroid and of the thymus glands, which, like this, are, as it were, extravasated in the space that separates them, they are unprovided with reservoirs, and their use is quite unknown. The great quantity of blood with which the lymphatic glands of the infant are imbued, is, no doubt, connected with the superabundance of this fluid. In the adult, a great quantity is still found in the bronchial glands, where it is of a dark colour. Some physiologists have admitted, but without the support of anatomy, that it partly contributes to form the black saliva expectorated on rising in the morning. Fourcroy, in particular, is of this opinion; he attributes much importance to the black hue of these glands, that might be, according to him, the reservoir of the carbon of the blood. The fact is, they belong to the lymphatic system; that in a great number of subjects they are found either of a greyish or of a reddish colour; that we know of no excretory organs belonging to them; that their tissue is of a pulpy nature like that of every similar gland; that their volume, however, distinguishes them from all the others. I have remarked that the dark colour of these glands, and of the continued fluid, is little affected by the action of acids, alkalies, or by boiling.

The absorbents ramify in the proper tissue of the lymphatic glands; after having entered it in a certain number, and each of them by numerous ramifications, they divide on their exit in several other branches, which give rise to an infinite number of ramifications. Each gland may in this respect be considered as a centre of two small capillary systems, opposed to each other, and anastomising together. In the interior of these glands these ramifications, excessively flexible, are folded together in different ways, occupy a considerable part of the peculiar tissue of these organs, so that several have in consequence been thought to be nothing more than the interweaving of the absorbents,—an idea without foundation, since this tissue has not yet been properly investigated.

I have observed that it is less susceptible of contraction than the greatest part of the other animal tissues: it approaches in this respect that of the real glands, but differs from it in this respect, that, instead of becoming harder by boiling, it soon softens, and is converted into a pulp, and on pressure dissolves under the finger. Acids, after having caused this tissue to skrink, also reduce it to a fluid state much sooner than many other tissues: this is remarkable when the sulphuric or muriatic acids are employed. When submitted to the action of alkalies, it loses a few of its principles, and the strength of these dissolvants is reduced, but it is never completely dissolved.

ARTICLE III.

Properties of the Absorbant System.

We shall consider the properties of the absorbents, and those of their glands, in the same article.

SECTION I.

Properties of the Tissue.

Extensibility of the tissue exists in the absorbant system; in fact, 1st. The thoracic duct may be considerably distended by injection before its peculiar membrane lacerates. 2nd. I have stated that the absorbents, round the serous membrane of a living animal, in the liver especially, often display rather considerable swellings or dilatations. Are these dilatations varices? Is there, in this respect, any analogy between the absorbents and the veins? I cannot tell. Let this be as it may, they may be very considerable in the remote absorbents. 3rd. Whenever the thoracic duct has been tied, it not only swells, but the lymphatic vessels of the abdomen also become dilated; and this ligature is the best means of obtaining a proper investigation of the lacteals. This extension has, no doubt, its limits: if too great, it would probably, in the natural state, occasion the laceration of the vessel, which is the case in injecting.

In respect to these lacerations, we have hitherto obtained no information, supported by inspection or experience, although many authors have pretended to explain by this the cause of the greatest part of dropsies.

The contractility of the tissue is evident in the system we are now considering. 1st. When the thoracic duct is distended, even in the dead body, (the subject being recently deceased,) and the fluid has been discharged by puncture, the organ instantly contracts. 2nd. Every absorbent also contracts the moment it becomes empty. This phenomenon is particularly striking during the absorption of chyle; as soon as it is completed, these vessels gradually disappear, in consequence of this contraction. 3rd. Absorbant glands considerably distended at the moment the chyle enters, are subsequently much reduced in size by contraction.

SECTION II.

Vital Properties.

But little information has been obtained respecting the animal properties of the absorbents; they do not appear to possess relative sensibility; the attempt to prove it by experiments is attended with the greatest difficulty. When a lacteal filled with chyle is punctured, or a lymphatic filled with serum on the surface of the liver, or again, the thoracic duct, the animal gives no signs of pain. But what induction can be drawn from this, under the circumstance of the abdomen being laid open: admitting even that this sensation existed, how very light it must appear when compared with the continued and excruciating pains experienced in such circumstances. No experiment, I believe, has yet been attempted, to ascertain if irritation directed towards the interior of those vessels has produced pain, probably in consequence of the analogy of structure and continuity of the peculiar membrane; in both systems, the same result might be obtained from injections performed with this view, as from those made in respect to veins.

There is one circumstance, however, in which the absorbents are keenly sensible, namely, in their inflammations. An obstruction and even a very striking redness, along the course of the subcutaneous absorbents in the inferior extremities, terminating all the inguinal glands, or even exceeding them, producing the most acute pains, is a phenomenon frequently observed in diseases. In cuts with an instrument impregnated with any virus, in the acute pain attending the whitlow, &c., a very painful sensation is frequently experienced along the absorbents of the upper extremities.

In their natural state, when irritated in various ways, which is easily performed, the lymphatic glands do not appear to possess animal sensibility. Inflammation, however, is apt to develope it in these glands as well as in the absorbents, by increasing considerably their organic sensibility. Thus pain is very acute; if these glands become inflamed subsequent to a puncture made with an infected instrument, or after a sprain, the acute sufferings that attend those of the arm-pit when they are obstructed and suppuration takes place, are sufficiently known? Shall I mention those felt in the mesenteric glands when cancerous? or what is much more common in buboes, &c. &c.

Neither the absorbents nor the glands are possessed of animal sensibility. The organic properties of the absorbents present the following disposition. Haller admits that sensible contractility exists in this system. He formed this opinion from having observed that the lymphatics readily emit the chyle that circulates through them, and from their contraction when brought in contact with sulphuric acid; but this, as well as every concentrated acid and caloric, will produce the same effect on every animal substance, even after death: namely, a shrinking. When the absorbents, and particularly the thoracic duct, are touched with the point of a scapel, no contraction is ever observed. If sensible of contraction, it seems to be when they have ceased to be distended, and not when they have been irritated; consequently it is performed by the contractility of the tissue. Sensible organic contractility is, therefore, at least doubtful in this system, or if it exist, it is very obscure, and at the utmost can only be compared with that of the dartos.

The absorbents are evidently possessed of organic sensibility, and insensible organic contractility. It is by these properties that they perform their functions, and the fluids are circulated in their ramifications, &c. &c. These two properties are here so much more remarkable, as they survive death itself for some time. A fluid injected when the animal still retains some degree of heat, is absorbed either on the serous surfaces, or on the mucous, and less so in the cellular tissue. This faculty of absorbing might even be continued by maintaining heat artificially, by means of a bath; but this process is less efficacious than I at first thought; for a long time, various experiments have contributed to undeceive me. This undoubtedly proceeds from the vital heat, and not the artificial heat, being required for the exercise of this function, or rather vital heat and absorption are two effects of a common cause; namely, of organic properties. As long as these properties remain adherent in the solids, they retain caloric and will absorb; the instant they disappear, heat disappears, and absorption ceases at the same time. It would be useless to expose bodies deprived of life to the action of caloric; they may be warmed, but will never produce any vital phenomenon. In the same manner if heat be perpetuated for some length of time in an animal recently killed, by substituting artificial for natural heat, it is to no purpose. It is the decline of organic sensibility and insensible contractility, that should be prevented in order that absorption may be continued, and whenever this power is retained it can only be by previously maintaining these properties. Notwithstanding what Mascagni and many others have said, absorption cannot be relied upon when the animal is cold: in such instances I have frequently but unsuccessfully attempted to put it in action; generally speaking, I have never observed it to act more than two hours after death. Organic sensibility in the absorbents is connected with different fluids, which perfectly distinguishes it from the other systems; for instance, from the glandular, that is never connected but with a particular fluid, and which in the natural state rejects every other. Water and other mild liquids, although very distinct from the lymph, may easily be absorbed in the natural state, the thoracic duct will alternately admit chyle, lymph, &c.

Characters of the Vital Properties.

From what has just been stated, it is evident that in the vitality peculiar to the absorbents the organic properties act the most important part. These properties are much more characterized in this system than in the veinous; at least they more readily admit of increase. In fact, ten instances of inflammations in the absorbents are found to one in the veins. The facility with which they admit of this affection, from the slightest virus flowing through their tubes, from pain experienced in their extremities, is a special character of these vessels. Those obstructions, pains, and inflammations, so very frequently ascertained in the track of the absorbents, are rarely met with in the course of a vein. This distinction denotes a diversity of structure in the proper membrane, although it be continued with that of the veins. In fact, at the time when experiments on the transfusion of medicaments in the latter vessels were tried, authors have not related a single case of veinous inflammation caused by the contact of the heterogeneous substances with the membrane of the veins, whilst practice frequently proves this fact in respect to the aborbents.

The lymphatic glands particularly have a great tendency towards inflammatory obstruction, when they come in contact with absorbed deleterious substances. At first the effect produced by these substances is limited to the first glands they meet: thus it is that the absorption of venereal infection hardly ever passes beyond the glands in the loins: thus, also, those of the axillary glands alone become swelled subsequent to a puncture with an infected instrument, &c., whilst those further removed remain uninjured.

Notwithstanding this excessive tendency to inflammation, the lymphatic glands, however, are much slower in their progress in this affection than many other animal tissues, than the cellular and cutaneous for instance. It has been sufficiently proved that phlegmon and erysipelas have gone through their periods in a shorter space of time than the axillary or inguinal glands require in their states of inflammation, &c. The nature of pain in these glands, when inflamed, is very distinct also from that experienced in the above-mentioned affections; it is a dull and obscure pain, as it were, and more time is required to form pus, and it might rather be compared to that of the cellular tissue, being very distinct from that formed in erysipelas. Few tissues in the economy, subsequent to inflammation, are more liable than this to be hardened ; if, subsequent to erysipelas, the skin become schirrous in one instance, the lymphatic glands will be so in twenty. This is, in fact, one of their distinctive characters.

The absorbents, as well as their glands, frequently display, in a certain degree, a slowness in the progress of those phenomena over which the organic properties preside: for instance, whenever they have been injured in wounds they contract and shrink, and require more time for healing than the capillary vessels similarly affected. Hence, the serous discharge that is continued for some time after hemorrhage has ceased, a phenomenon that is invariable in slight wounds; but it would certainly not be the case if the absorbents and the capillary vessels were possessed of the same mode of insensible contractility.

There are additional proofs of the principles, the consequences of which we so frequently had occasion to produce instances of in the course of this work, namely, that the vitality peculiar to each system imparts to every affection its peculiar colour and aspect, if I may be allowed the expression, which are foreign to all the other systems.

Difference of the Vital Properties in the Absorbents and their Glands.

Although at the same time we have treated of the vital properties in the glands, and in the absorbents—although anatomy represents the former as an assemblage of numerous vascular folds and windings, yet it cannot be doubted that they are possessed of a peculiar mode of vitality, which distinguishes them from the absorbents that resort to them. It is this peculiar mode that makes them liable to certain diseases that are not so in the absorbents: scrofula seems to affect them in particular. In the innumerable cases of obstructions which arise after organic diseases of these organs, the tissue of the absorbents does not appear simultaneously injured. It even appears that in a number of cases, the numerous windings of their tubes in the glands are not organically affected; in fact they transmit the lymph as usual. Nothing is more common than to find the abdominal and thoracic obstructions of these glands unattended, in infants, with serous infiltrations, even in their most advanced periods. I have frequently been struck with this phenomenon in dissecting young subjects. The lymphatic vessels are apparently not more than usually dilated. It rarely happens that at this stage of life we can discover them for the purpose of injection.

Sympathies.

The absorbant system is very liable to be sympathetically influenced by the other organs. This disposition relates; 1st. To the glands; 2dly. To the vessels.

One of the phenomena the most frequently disclosed by dissection, is the swellings of the lymphatic glands in organic affections of the important viscera. This phenomenon is observed, 1st. In the neck, in respect to the jugular glands, from the affections of the thyroid gland, and sometimes, from those of the larynx. 2dly. In the chest, in the axillary glands, and frequently in those of the mammæ; from cancer in the breast, and in those which surround the bronchiæ; from every species of phthisis, but seldom or ever from diseases of the heart, whether aneurism, ossification, or affections of the valves. 3dly. In the abdomen, in cancerous diseases of the stomach, particularly of the pylorus, and in the greatest part of those in which the tissue of the liver is altered, the mass of glands that attend the biliary vessels, and those which surround the pancreas are tumefied; so are the mesenteric glands, in cases of schirrous of the intestines, and of the urethra, which is generally rare. In diseases of the womb, of the rectum, of the bladder, the glands of the pelvis become tumid, and in schirrous testicle, the urethra, and the inguinal and lombar glands are also found in the same state.

These swellings of the lymphatic glands are of the same nature as the affection that has produced them, they are consequently acute or chronic, accordingly as the primary disease assumes either one or other of these forms. The swelling of the glands in the arm-pit is acute if it be the result of a puncture in the finger, or of a whitlow, &c., chronic if caused by a cancer.

It is far from my intention to represent these different swellings as the result of a sympathetic influence exercised over the gland; the passage of particular substances, as when a virus is absorbed, or a part is punctured with a poisoned instrument, &c. undoubtedly take the most essential part.

Sometimes, however, sympathy is the only cause when the glands are obstructed in consequence of the violent pain caused by a whitlow, by a splinter of wood introduced under the nail, or the bruise of a finger; whenever these glands are swelled by the application of a blister on the arm, or fore arm, &c.; when a similar phenomenon, of which I have seen many instances, is observed in the inguinal glands after a blister has been applied to the thigh, or leg, &c. &c., no matter can be conveyed to the gland; it is an effect of sympathy.

The generality of surgeons have thought that every cancer in the breast, attended with obstructed glands, should be extirpated. I admit that in some cases they may become cancerous, but I much doubt if this be the case in the greatest number. In fact, 1st. In old ulcerated cancers of the breast, they remain obstructed for life, without breaking: 2dly. After extirpation, when some too deeply situate could not be reached, they are seldom found of a carcinomous nature. Whenever the cancer returns, it is the wound that has opened again. 3dly. I have frequently compared the tissue of the gland in the arm-pit affected by a cancer in the breast, with those of the bronchial glands in phthisis, with the sub-hepatic glands, also tumefied in cases of steatoma, of hydatides in the liver, &c., but never found any difference. 4thly. In fine, every professional man who diligently attends dissection, may easily convince himself, that in almost every disease of the organs that are surrounded with a number of these glands, they become tumid, let the disease be what it may. I have myself been so far struck with this phenomenon, that for some time I attributed the depositions, in which almost every organic disease terminates, to the obstruction the lymph meets with on crossing those glands. The non-existence, however, of these tumefactions in diseases of the heart, attended with dropsy, the frequent absence of swellings in the superior extremities coinciding with the axillary glands obstructed the infiltration of the inferior parts, the glands above only being tumefied, and several other similar proofs, that have induced me to consider these serous infiltrations as passive exhalations, analogous to those produced in the hemorrhage, no longer admit of this opinion.

It is very important to form a proper distinction between the swellings of the lymphatic glands, in consequence of disease in the adjacent organs, from those which form the tumid belly of infants, and other scrofulous affections. 1st. In the latter instance, the tissue of the gland is always first affected; in the former, never but in an indirect manner. 2dly. This swelling is peculiar to infancy; the preceding one embraces every stage of life. 3dly. When a gland swells from sympathy with another organ, it generally retains its natural texture and colour. It is only in the latter periods that the tissue becomes harder, cartilaginous, and even suppurates, but there is not that change of the tissue, which takes place in the mesenteric and bronchial glands, swelled by scrofulous affections. The appearance and texture are quite different. The latter presents in that case a white substance, not very abundant at first, so that by dividing the gland, this substance is readily distinguished from the tissue, which is found in its natural state. At a later period, this white matter invades the whole gland, and the texture has disappeared. In phthisis, however, and sometimes, although not so frequently in cancers, the glands that have become tumid in consequence, present a similar appearance; but it is quite different in every other case.

We are aware, that in particular fevers, nature selects these glands to form the crisis, they are the seat in low fevers, of what is improperly termed parotid.

The absorbant vessels, as well as their glands, are influenced by the affections of the adjacent organs; I am thoroughly convinced, that the various alterations the absorption of chyle undergoes, that of the liquid part of bile and urine, the derangement of those of the serous surfaces in many diseases, are nothing more than sympathetic effects; but it is not easy to ascertain when this is the case. There are certainly sympathetic absorptions, as well as sympathetic exhalations and secretions.

On the other hand, it frequently happens that the absorbents being affected, the other organs are affected by sympathy; in the tumid belly, and in the obstruction of the bronchial glands that correspond to it, there are a number of symptoms visibly arising from the sympathies that connect these glands with the other organs. To point out these symptoms is not my present object.

In respect to the influence of the diseases of the absorbents over the other organs, we know but very little. When, after a puncture or a cut is made with an infected instrument, &c., they are inflamed in their course, vomiting and diarrhœa, &c. frequently ensue.

ARTICLE IV.

Of Absorption.

SECTION I.

Influence of the vital Powers upon this Function.

THE functions of the absorbents are no longer doubted by any anatomist; but the manner in which these functions are performed is far from being as correctly ascertained. The very first idea has been to compare the action of the absorbents with that of the capillary vessels, but, however little we consider this action, it will be easily perceived that these phenomena are perfectly distinct from those of the inert capillary vessels. I believe it will never be precisely ascertained how the orifices of the absorbents, immerged in any liquid, take and deposit their particles and convey them to ascend their tubes. But what is indisputable in absorption is, that the vessels are indebted for this faculty to the vital powers allotted to them; that it is merely the connection between their peculiar mode of organic sensibility, and the fluids with which they come in contact, that is the immediate cause of the phenomenon. If proofs are required, let us only observe the lacteal vessels select chyle exclusively from amongst the mass of matters contained in the intestinal tube; let us also observe the lymphatics of the urinary bladder, and that which contains the bile, leave a number of the elements of urine and bile, and only select the watery part of these fluids; again, the absorbents of the skin, those of the mucous membranes, and of the bronchiæ, &c. leave to air a number of principles, and only absorb a few. Frequently inactive for a considerable time, they are suddenly excited when some substances with which their degree of sensibility is connected comes within their reach. Let us consider that the fluids injected or effused in the cellular tissue, which are either taken up or left by the absorbents of that tissue, accordingly as they are adapted or not to their sensibility, quickly disappear or stagnate to form depositions in those parts.

It cannot then be denied, but that in the natural state the sensibility of the absorbents has a particular type, accommodated only to certain substances, which, on this account, can alone be absorbed. The exercise of organic sensibility, then, always precedes absorption in the same manner as it precedes secretion, nutrition, &c. Thus, in the phenomena of physics, the operation of gravity always precedes the fall of heavy bodies;

thus, again, the power of attraction existed before the motion of planets could be effected, &c.

SECTION II.

Varieties of Absorption.

FROM what I have just stated, it follows that whenever the organic sensibility of the absorbents is at all changed, absorption is necessarily affected, which in fact is constantly the case. In dropsies, the orifices of the absorbents are immersed in serum, their sensibility being sufficiently excited to take up this fluid, but let any cause whatever increase this property, and absorption instantly takes place. Some indolent tumours remain in the same state for a long time by the stagnation of their fluids, and then disappear if peculiar medicaments applied to them happen to rouse their absorbents from their torpid state. It is not then on the fluids the resolvents act; they do not dilute them, they do not separate them, according to the vague expression of physicians, but by altering the mode of power in the absorbents they render them fit to act. It is so perfectly true, that resolution of parts takes place in this manner, that frequently a slight degree of inflammation is first requisite for its production,—every surgeon is aware of this. Desault did not consider the greatest part of obstructions in the testices as an obstacle to the operation of hydrocele by injection; on the contrary, frequently after the irritation produced in the testices by the inflammation of the adjacent membrane, he has succeeded in dissipating what had only been retained by a deficiency of energy in the absorbents.

The alterations in the organic sensibility of the absorbents, may either increase, diminish, or differently modify that property. Let us then, in consequence of this, cease to wonder at the excessive varieties of absorptions; let us cease to wonder, if, besides the fluids usually taken up, a number of others may be conveyed to the blood through the absorbents; if bile, urine, or the mucous juices that are commonly repelled, can be admitted into the circulation; if the blood effused in the cellular tissue is returned by these vessels, the vital powers, from the excessive variety, impart the same character to all the functions over which they preside.

Much has been said of putrid matters having been conveyed to the mass of the blood, and to this the causes of diseases have been referred. This infection of the blood has been too much exaggerated, but in many instances it actually exists Why are the hue, the consistence, the smell, and nature of the fæces, so very variable? If similar substances were constantly absorbed from food, it is evident that the residue of that food would always be the same. Let us consider the innumerable varieties of urine, of bile, of mucous fluids, &c., according to the difference of he principles that contribute to form these fluids, why should not the chyle present the same varieties? it would be different from the other fluids of the animal economy, if its nature did not alter in a variety of instances. Now, from what could these varieties proceed, if not from the lacteals presenting innumerable varieties in their organic sensibility, which will only admit of particular principles, and rejects the others?

The absorption of the lacteals, which, in the natural state, convey to the blood nothing but nutritive substances, may then frequently leave a passage for the admission of morbid principles. Thus, in the lungs, the vessels that borrow from the air the principles required to colour the blood, are often found to convey principles that prove fatal to the functions, according to the different alterations their sensibility may undergo.

In the ordinary state, the mode of organic sensibility and of tone in the cutaneous and mucous absorbents close every passage to deleterious substances from without; but let this sensibility be altered and instantly the passage is opened again. Does not pus in the greatest part of wounds remain in the cellular tissue? but if, by some improper application, the power of the absorbents be increased, it is taken up by them, passes into the blood, and the ulcer becomes dry, and hence the whole of the symptoms proceeding from absorption.

It may be said that thousands of passages are always open in our organs to admit noxious principles. Placed as a centinel at their orifice, the organic sensibility, according to the manner it is affected, warns the insensible contractility when they are to be opened or contracted.

It is exhalation that contributes to form the greatest part of tumours; it is absorption that effects the cure.

If I intended to follow the phenomena of absorption through the different stages of life in the sexes, in the seasons and climates, I should be continually showing the differences of organic sensibility that always precede the variations of this function. I shall speak of it in respect to the different ages.

The causes that alter the natural type of sensibility in the absorbents, are, as in respect to every other function, either direct or sympathetic.

1st. Direct, as when by friction on the skin the absorbents are excited and brought into action, which would not otherwise have been the case.

2dly. Sympathetic, as when the absorbents partaking of the affection of a distant part increase or diminish their action accordingly as they are influenced. We have treated of this phenomenon amongst the sympathies in the different systems.

SECTION III.

Motion of the Fluids in the Absorbents.

When once absorbed from the different surfaces we have mentioned, the fluids move successively till they reach the common trunks that transmit them to the veinous system.

We are ignorant of the laws of this motion. It is evident, however, from several observations previously adduced, that it bears a striking analogy to that of the veinous system, but it is also distinguished from this by a variety of differences.

In general it appears slower in its progress. The thoracic duct, if opened when filled with chyle, does not emit so large a stream as that from a vein.

The motion of the lymph does not appear like that in veins, to be liable to a reflux on approaching the heart; for instance, the venæ cavæ, and jugular veins, &c. may be so much the more dilated, that the lungs, obstructed more than usual, oppose a greater obstacle to the blood, which retrogrades. Now I have never observed in injecting the thoracic duct between its dilatation and contraction, and the state of the pulmonary organ, the least contraction. On the other hand, this canal is never found so filled with lymph as a vein is with blood, when in the last moments the course of the fluids is impeded.

How does it happen that in the reflux that forms the pulsation of the jugular veins, the blood does not enter either of the absorbent trunks? The valves so disposed as to prevent the entrance of this, which in the natural state flows towards the heart, are evidently of no use here. This phenomenon can certainly be ascribed only to the connection between the orifice of these trunks and the dark blood, in the same manner as the orifice of the larynx, unconnected with external substances, rejects every fluid except air. Blood is never found in the thoracic duct.

There is evidently in the veinous blood an uninterrupted motion from the capillary system up to the heart. It proceeds, as it were, from this system, to be directed to that organ. The motion of the lymph, on the contrary, is incessantly interrupted by the glands, each of which, as I have already stated, actually displays in respect to the vessels that cross them, a minute capillary system. On reaching each gland, the impulse of the motion is unavoidably changed. Now, as the state of these glands admits of numerous varieties, it will be easily conceived how the motion of fluids, circulating through the absorbant system, must necessarily admit of numerous variations; that this motion may be rapid in one part, slow in another, regular in a third, irregular in a fourth, &c. Hence we ought not to wonder if particular absorbents only are dilated, whilst the adjacent ones are hardly perceptible. There is actually a kind of variety in veins; but its source is within the origin of these organs, and is never observed in their course, which is the case with the absorbents.

The continuity of the veinous blood, and the frequent interruptions in the circulation of lymph, must produce distinctions not only between the motions in each order of these tubes, but also in the composition of their respective fluids. The former is necessarily the same throughout; the latter may vary between each gland, and assume new modifications in every one that it crosses.

I should feel rather inclined to believe that the insensible contraction of which every minute capillary system is susceptible in every gland, accommodates the motion of the lymph, by reducing the distance which this fluid would have to pass without a fresh impulse from the origin of the absorbents, till it reaches the dark blood, if these organs were wanting. In fact, it has been sufficiently ascertained, that in the extremities where they are more sparingly disseminated, infiltrations more frequently take place than in the trunk incessantly overrun with absorbents; I mean those infiltrations which must evidently be referred to a want of circulation of lymph; such as those proceeding from compression, a fixed posture too long continued, &c. and by an increased exhalation subsequent to organic affections.

From what I have hitherto stated, it may be observed that we have still but a few unconnected notions respecting the circulation of lymph; that the motion in the veins, although requiring more extended researches, is better known, and that to present a sum of proper investigation on these two points, especially on the former, much ulterior labour and many experiments are required.

SECTION IV.

Of Absorption during the different Stages of Life.

In the fœtus, and in the infant, the absorption which relates to nutrition is not in proportion to exhalation; a number of substances remain in the organs: few are expelled; hence growth.

The interior absorptions of synoviæ, serum, fat, marrow, &c. &c. are but imperfectly known in their differences at those stages.

The external absorptions appear much more active; for, as it is well known, we take infection much more readily in the early years of life; it has not yet, however, been ascertained whether the skin and the mucous surfaces always convey more heterogeneous substances in the economy, or if they are merely disposed to admit them.

We are very far from having any positive information respecting the state of absorption during infancy; but if we judge by that of the lymphatic glands, it would appear it must be most energetic: in fact, these glands are comparatively very much developed, they contain the focus of very active functions; their degree of vitality at that age is more striking than will be found afterwards: hence a greater pre-disposition to disease. We are well aware that, until the age of puberty, or rather till growth is completed, these organs are the focus of numerous affections which entirely subside after that stage of life, and are to be deduced from the extensive series of those to which we are disposed.

The following circumstances; 1st. The early, and proportionally the more considerable, developement of the lymphatic glands in the infant.

2dly. Their pre-disposition to diseases strongly characterized, most certainly denote a considerable degree of activity in their functions, because it implies a remarkable increase of the vital powers, and these being greater, must unavoidably preside over very energetic functions. In fact, if we only consider the organs whose functions have been ascertained, and which in infancy are, on the one hand considerably developed, on the other strongly disposed to disease, the functions of these organs are more active. Thus when the brain and nerves are strongly characterized, sensibility is more active. Thus again, when larger than usual the vessels of the arterial system are connected with abundant nutrition, &c.; in youth, it is when the genital organs unfold the most, and that they are the more exposed to disease, that their functions become more striking. If we examine every organ and their functions, we shall find that a general law of the economy is included in the three following facts, which are constantly united, namely:

1st. Considerable developement.

2dly. A stronger tendency to disease.

3dly. More activity in the functions.

Now, since the two first exist together in the glands of the absorbents, we must conclude that the third is superadded, although we cannot positively prove it, since from what has been stated, we cannot ascertain the uses of these small organs. Grimaud, it is true, actually considered them as essential to nutrition, he has even denominated the whole mass of these glands, and of the cellular tissue, the nutritive system; an idle supposition without foundation. All we know on this point is, that nutrition on one part, the developement of these glands on the other, are very forward in the fœtus; but does it follow from this, that the former phenomenon is derived from the latter?

certainly not; no more than if, because the brain and the liver are much developed in the fœtus, and that nutrition is very active in this subject, we mistook these organs for the agents of this function. Each organ is itself the machine, that separates from the blood and from the fluids conveyed to it, the nutritive substances that are adapted to them, to appropriate them subsequently. The muscle separates the fibrine, the bone, the calcareous phosphates, &c. but there is no common and central organ to elaborate these nutritive matters, as there exists a common viscus to move the blood and a central organ to preside over sensibility, &c.

In regard to the anatomical state of the absorbents in the fœtus and in the infant, we cannot ascertain it. I have never heard that any author has injected them in those stages, to compare them with those of the adult. I possess but one single fact on this head. It is, that the lacteal vessels examined in an experiment performed on two young dogs, only eight days after they had left the mother, have appeared to me proportionally larger than at a more advanced age. I shall make a remark in this respect which I have been struck with; it is, that the stature has less influence on the diameter of these organs than might be supposed; for instance, these vessels are not double the size in an adult dog, that is, twice as large as another. Chance enabled me to consider them the same day three years ago, in two large greyhounds that were brought to me with other dogs, and in one of that species commonly called pug, I was surprised to find them nearly equal in all three.

We are but imperfectly acquainted with the various revolutions absorption undergoes in the different stages of life, subsequent to childhood; but it cannot be doubted but the predominance of the lymphatic glands in the economy subsides when puberty begins: the period for their diseases is then elapsed; frequently even these diseases, which had so far resisted all medical assistance, will spontaneously subside. The predominance of the genital organs, which succeeds to this and to a few others, such as those of the sensitive organs, &c., appears to suppress the source of the former.

Sœmmering, in a separate work, has pourtrayed the action of the absorbents in the different diseases of the adult, and the other stages of life. This, notwithstanding what he says, appears to me very difficult to ascertain; in regard to this subject, I refer to his book.

In old age, nutritive absorption remains tolerably active; for it is this function that dissolves the body, that robs it of its substances, consequently that withers and dries up the organs. The external absorptions, on the contrary, are not striking; the skin, as I shall state when treating of that organ, takes in contagion with great difficulty; the mucous surfaces absorb slowly: a small proportion of chyle, when compared to what takes place in the adult, is received by the blood. Both absorptions, the nutritive and the external, are then completely reversed in the two opposite stages of life: in infancy, the latter predominates over the former, in decrepitude it is quite the reverse.

In respect to external absorptions, such as those of the synovia, of the serous surfaces, of the cellular tissue, &c., I am led to believe they predominate in the aged subject, and that to this must be attributed several infiltrations and effusions that occur at that age, and which we observe in the dead body. Besides, we have not in this respect such substantial proofs as we possess in regard to the two others.

SECTION V.

Accidental Absorption.

Two things might be understood by this expression:

1st. The absorption of fluids distinct from those naturally taken up by the absorbents, such as extravasated blood, &c.; I have already mentioned this kind of absorption.

2dly. That which takes place in cysts that are formed against the natural order of the economy. Now this displays, by comparing it with accidental exhalation, rather a singular phenomenon: in fact it is performed but with difficulty. We rarely see the fluids of encysted tumours suddenly returned either wholly or in part to the circulating mass, which is not uncommonly the case with the serous collections of the peritoneum, which without cure are often alternately filled and emptied. Is there a physician that has not in such cases remarked the urine to flow in proportion as the abdomen is depressed, or that fluid suppressed when it fills again?

Let us observe on the contrary, that exhalation is renewed with the utmost facility in encysted tumors; that if they are emptied, and their removal has not been attended to, they will soon, as I have stated, return again. Whether the absorbents developed in these tumours are in proportion to the exhalants I cannot tell; but the fact is nevertheless correct; diseases prove it daily.

END OF THE FIRST PART.

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